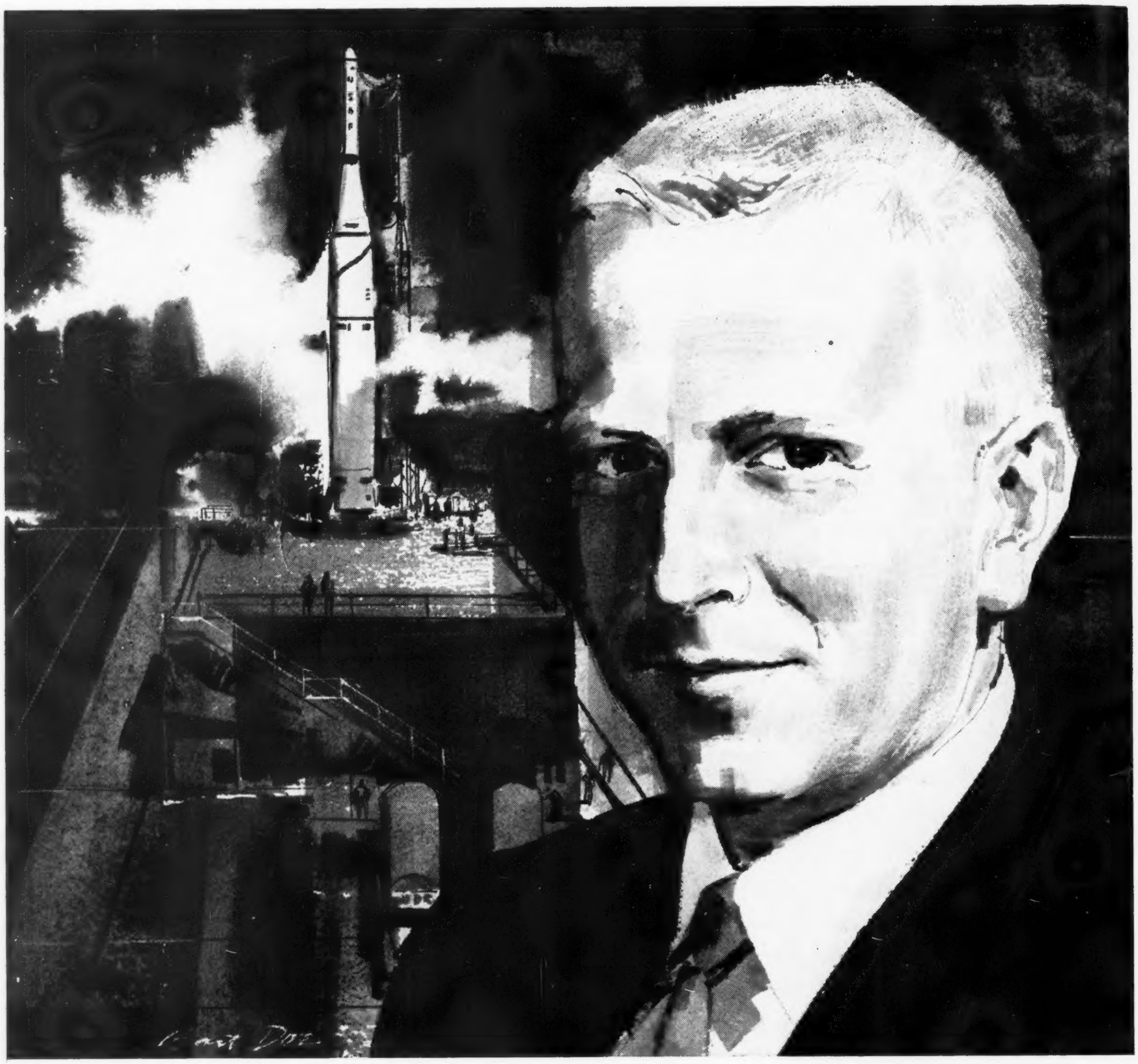
Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

SEPTEMBER 1959

ASTRONAUTICS DECIMAL CLASSIFICATION SYSTEM



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September 1959 volume 4 number 9

EDITORIAL

FEATURES

EDUCATION

DOCUMENTATION

DEPARTMENTS

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Astro notes

SATELLITES

• NASA, AF, and STL joined hands last month to place the 142-lb Explorer VI "paddlewheel" satellite in the widest earth orbit achieved to date: Perigee, 157 st mi; apogee, 26,400 mi; period, 12 hr 45 min. Equipped with 8000 tiny solar cells to meet its total space power needs for a year or more, the NASA satellite is the brainiest and most sophisticated satellite to date, far exceeding anything put up by the Russians.

• Paddlewheel has several roles. As a scientific satellite, it will measure Van Allen and cosmic radiation in great detail, map the earth's magnetic field, keep track of micrometeorites and provide a crude TV image of the earth's cloud cover. As an experiment in space technology, it carries a prototype of an interplanetary communications system of 50-million-mile range, as well as the first digital memory and readout unit known to have entered orbit.

• Heart of the Paddlewheel experiment is a receiver and 40-watt uhf transmitter operating on an undisclosed frequency. The receiver can handle 30 different ground-command functions within the satellite, including operation of the primary transmitter and the digital memory unit (called "Telebit"). One of the command functions is the firing of a 5-lb "kick rocket" located at the top of the spheroid to raise perigee altitude. It has not been necessary to fire the unit because the initial orbit exceeded expectations, but it may be used later.

• Peak power requirement of Paddlewheel is 45–50 watts when the main transmitter is in use. The solar cells are expected to provide 30 watts or more almost continuously (the satellite will spend most of its time in the sunlight), with nickel-cadmium batteries making up the balance. Latter will be recharged when the 40-watt transmitter is turned off. There are also two low-power tracking beacons in the satellite sending continuous analog telemetry on all the experiments at 108.06 and 108.09 mc.

• While STL has relied entirely upon a surface coating to hold Paddlewheel's internal temperature to about room temperature, an interesting temperature control experiment was placed in the payload to determine the usefulness of self-regulating heat controls in future satellites. The device consists of a black patch on the side of the satellite over which a stubby, four-bladed vane may turn. The latter is rotated back and forth by a spring inside the satellite which expands in heat and contracts in cold.

• Paddlewheel was actually the second "Explorer VI" to be launched in three weeks. Its immediate predecessor was a 92-lb payload launched by an Army Juno II. Referred to as the "clean-up" satellite for the Vanguard program, it suffered an ignominious fate when the launching vehicle failed to program properly and had to be destroyed a few feet above the launching pad. In erasing the Army project from the books, Deputy NASA Information Chief Herb Rosen said the civilian space agency henceforth will only give designations to vehicles which actually return data from space.

• Anxious to redeem itself, the Army has offered to make available another Juno II by Sept. 30 to launch a spare of the 92-lb clean-up package. NASA is likely to accept the offer because U.S. scientists want to get a look at the sun before it turns quiescent. The payload package contains cosmic ray, X-ray, and Lyman Alpha radiation measuring instruments, and Werner Suomi's heat-balance experiment.

• Initial development contracts have been awarded for Project Courier by the Army Signal Corps. Acting on behalf of ARPA, the Signal Corps gave Philco a $3.6-million contract for the communications package, ITT a $4 million award for ground communications stations, and Radiation, Inc., a $1.3-million contract for ground antennas. First of the 500-lb Courier satellites will be launched within a year in a 500-mi orbit and will be able to handle up to 40 incoming and outgoing teletype messages simultaneously.

SPACE VEHICLES

• Difficulties involved in building a manned lunar vehicle in space are pointed up in Milton Rosen's Nova paper for presentation at IAF Congress in London (see page 20). To build up capability in orbit for one such vehicle, eight successful flights of ARPA's Saturn booster would be needed. Then a crew would be needed in orbit to assemble, fuel, and checkout the vehicle. Also, the operation would undoubtedly be performed once to provide an unmanned lunar test flight before a man would be sent. Add the need for a spare vehicle, and you come up with a total of 24 successful Saturn launchings for the sole purpose of a manned lunar round trip.

• Saturn is going to be a big one—about 200 ft tall and weighing some 580 tons (500 of which will be propellants) at liftoff. Now planned as a three-stage vehicle, a fourth stage may be added later for certain missions. The first stage, made up of a cluster of eight Rocketdyne H-1 engines, will be about 75 ft tall, 22 ft in diam, and will give about 1.5 million lb of thrust. The second stage, a modified Titan, will be somewhat longer than the normal 54 ft, and 10 ft in diam. It will give 360,000 lb of thrust. The third stage Centaur will use two lox-hydrogen engines with a combined thrust of 30,000 lb and will also be 10 ft in diam. The vehicle will use all-inertial guidance, automatically compensating for deviations resulting from loss of thrust should one or more of the first-stage engines fail to function.

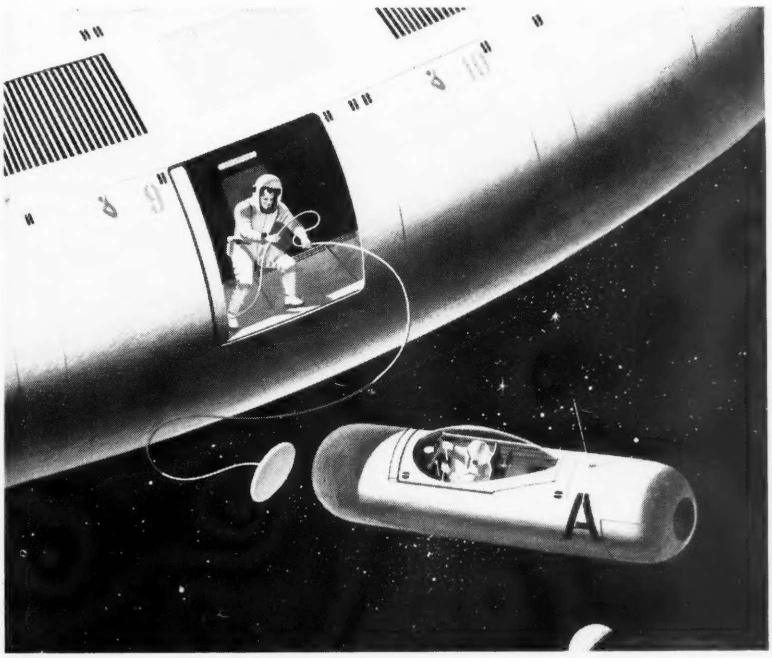
• Modification of ABMA's 145-ft-high static test stand at Huntsville to take Saturn is nearing completion, and the stand is expected to be ready this month. First test vehicle will be delivered in November, with first firing due in December.

• Attempts will be made to recover costly Saturn boosters at sea, with parachute-retrorocket combination used to bring the boosters back to earth. With first Saturn launchings due in 1960, conversion of ships which will participate in the program is already underway.

• Launching complexes, not vehicles or powerplants, represent the main hitch in the U.S. space program. Ballistic missile flight-test program, given top priority, cuts the number of launch facilities available for large space vehicles to a bare minimum, and funding for

COUNT DOWN!

for the conquest of space



WHAT KIND OF ENGINE FOR A SPACE-TAXI?

It takes a unique engine to jockey a space-taxi in for a landing on an orbiting space station—one that will give a space pilot instant control and precise maneuverability.

Such an engine is the fully controllable rocket engine—ideal for space travel yet as easy to operate as an automobile engine.

The rocket engines are ready now

Although the space-taxi is still a gleam in an engineer's eye, the controllable rocket engine is available now...and has immediate application for existing aircraft. The pilot of a plane with auxiliary rocket power can switch it on for sudden, swift acceleration at high altitudes . . . the aircraft's air-breathing turbojets supplying power for ordinary flight operations. This is the mixed-power theory. Since World War II several mixed-power concepts have been developed in foreign countries, including Russia, France and England.

Extra power for today's aircraft

Rocketdyne already has designed, tested, and manufactured rocket engines for mixed power applications. The AR-1 rocket engine is a liquid-propellant system, as are the large power plants for the Atlas, Thor, Jupiter, and Redstone ballistic missiles. The AR-1 passed stringent flight tests as a supplementary power plant on modern jet aircraft. Substantial improvements over normal near-sonic speed and 50,000-foot altitude capabilities were demonstrated in more than 100 test flights.

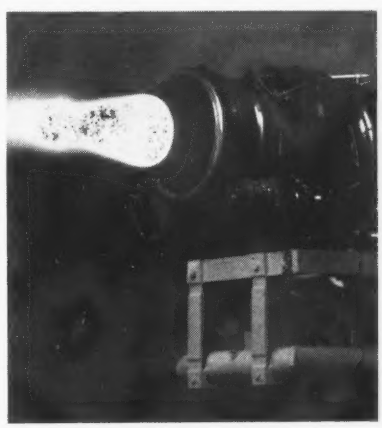
The AR-2, second in a series of four rocket-engine models developed by Rocketdyne, is a fully-throttleable engine that provides varied thrust. Using fuel from the airplane's tanks—which automatically ignites with hydrogen peroxide—these engines have full stop and restart capability.

More value for taxpayers' money

The auxiliary rocket engine gives present aircraft superperformance capabilities at a relatively low cost. It provides the increased speed and maneuverability that could spell the difference between the success or failure of an intercept mission. Almost any existing jet aircraft, as well as those now on the drawing board, can be adapted readily for AR engines.

Looking forward to tomorrow

Beyond a doubt, rocket power has a leading role in the Free World's future. Rocket-propelled airplanes, such as the X-15, will pave the way for man's entry into Outer Space. The multi-million-pound-thrust systems that are now under development at Rocketdyne will be man's means to explore interplanetary Space. But meanwhile, these rapid advances in rocketry can add great strength to America's present deterrent arsenal.



THE MEASURE OF ROCKET POWER

The liquid-propellant AR rocket engines are "static tested" at Rocketdyne's field laboratory to measure thrust and performance.

FIRST WITH POWER
FOR OUTER SPACE

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

new facilities is having tough sledding. The situation is so serious that contemplated NASA Mars and Venus shots in 1960–61 are imperiled, and may, in fact, have already been canceled.

• Aerojet has received a prime contract from the Army Corps of Engineers for design of a 6-million-lb-thrust test stand for Andrews AFB. Initial plans call for a two-position stand capable of handling two NASA 1.5-million-lb-thrust engines. The stand, largest in the free world, will ultimately be expanded to a single-position bay capable of supporting a cluster of four engines fired simultaneously.

• Aerojet has also received a multimillion-dollar contract from Douglas for 15 liquid-rocket engines for NASA's Delta vehicle.

SPACE RESEARCH

• U.S. plans to place a small seismograph on the moon within six years to measure "moonquakes" and answer questions about the composition and origin of the moon were revealed in NASA's announcement of $130,000 contracts to Columbia Univ. and CalTech for development of the seismograph. The one-year contracts mark the start of a project which may run to $1 million. Scientists at both schools feel a rugged seismometer, weighing only 10–20 lb, is feasible.

• Convair has submitted a proposal to NASA to search space near earth for evidence of anti-matter. Two experiments have been proposed, which could be packed into 50- to 100-lb space probe packages. One would search for positrons, the other would seek traces of past matter and anti-matter annihilations.

• AF Special Weapons Center is sponsoring a series of seven high-altitude rocket probes at Wallops Island which are intended to hurl 45-lb payloads of radiation measuring instruments from 750 to 2000 mi into space. Called the "Javelin-Journeyman" program, it will use multistage NASA solid-propellant rockets 48 and 62 ft in length. Since the program sponsor and most of the contractors are identical to those engaged in the Jason project last summer, which measured the man-made Argus electron shells in space, it appears likely that the latest program is somehow related to the earlier exercise, although AF refused to comment further.

• UK has reached a tentative agreement with NASA for a joint program in space research. The U.S. will provide four-stage solid-propellant Scout boosters to place three British scientific satellites in orbit within the next three or four years. UK will earmark $300,000 to $600,000 annually in a four-year program providing for construction of at least five satellites. Meantime, UK will continue with plans to adapt the Blue Streak ballistic missile for space missions.

MISSILES

• Far from being disappointed with Polaris test results, Rear Adm. William F. Raborn has assured House investigators he plans to accelerate his timetable for a full-guidance firing of the submarine-launched weapon. He based his decision on a remarkable Polaris flight in July in which the vehicle lost a jetavator yet stubbornly clung to its program, even describing a complete loop in order to do it. During the high-g maneuver, the second stage remained intact and fired at first-stage burnout.

• First Polaris launching from the test ship "Observation Island" was expected in about six weeks, Raborn said, while firings from Cape Canaveral will emphasize increasingly tactical versions of the system throughout the rest of this year. Raborn identified two design problems which have been troublesome, but said both have been solved. One involved the accretion of aluminim particles from the fuel on the jetavators and the other overheating of the aft end of weapon during transonic flight.

• Lt. Gen. Bernard Schriever, head of the USAF Air Research and Development Command, told House investigators that the causes of three of the five consecutive Atlas failures earlier this year were random in character, while two appeared to result from a design shortcoming in the fuel system. He expressed confidence Atlas could meet its Sept. 1 initial operational capability deadline at Vandenberg AFB. (This represents a two-month postponement in the IOC.) Schriever's apearance before the House Science and Astronautics Committee was sandwiched between two successful Atlas shots—the first since last February. The second was an Atlas-D, the operational weapon.

• Boeing awarded RCA a major contract to develop and install the command networks for Minuteman launch control.

• The Army, Marine Corps, and Convair-Pomona announced plans for joint development of the bazooka-like Redeye missile, a 3-in.-diam, 20-lb round which can be shoulder-fired from a tube launcher against low-flying aircraft with good effect owing to its infrared guidance system. The Army awarded Convair-Pomona $6 million for development of the weapon.

R&D

• Solid propellants with metal additives provided the basis for some tub-thumping in the past month. Finely divided aluminum can be incorporated in both double-base and composite propellants. Motors for Minuteman, Nike-Zeus, and Polaris reportedly contain aluminized propellants. It would not be surprising to learn that the metal turned up in complex molecules, rather than finely divided form, in some of these motors.

• Commenting on proposals to encapsulate highly reactive propellant constituents, Harold Ritchey of Thiokol said the company's research group has produced enough of an encapsulated combination to be used in a fair-sized rocket motor. Southwest Research Institute and National Cash Register have also thrown out hints that their research programs on encapsulated propellants may soon produce something workable in a rocket motor. This is a tricky field, involving potentially high manufacturing costs, but some news on encapsulated propellants may soon be forthcoming, especially from Thiokol.

• Mass spectrometer studies by William Chupka of Argonne National Lab have shown that at least six oxides of beryllium exist at 2000 K. This may be of interest to those considering beryllium as an external structural material on re-entry gliders.

• Under NASA contract, Acoustica Associates will study the modification of burning rate in solid-propellant rockets with a Levavasseur whistle driven by a gas generator. Besides offering a possible means of controlling thrust level, the device may prevent resonant burning and grain-sliver residue. An experimental version of the device

(CONTINUED ON PAGE 10)

O'er the ramparts...

U. S. Army's

NIKE HERCULES...

Solid rocket motor built by Thiokol for Nike Zeus has produced greatest mass discharge rate and thrust of any single

Through the combined efforts of the U.S. Army, Western Electric, Douglas Aircraft, THIOKOL Chemical and other key members of the missile industry, America is moving toward the realization of a critically needed anti-missile missile.

The Nike-Zeus system — big brother to the Army's Nike Hercules which now stands guard over major population centers — is being designed to detect, charge and destroy attacking ICBMs many miles from their targets.

Assigned development of the boost for the Zeus, THIOKOL has already designed, built and successfully test-fired a motor achieving over

Thiokol®

CHEMICAL CORPORATION
Bristol, Penna.

with controls and gas generator for 30-sec operation weighs 40 lb.

• Bell Aircraft will develop a flow system for storable liquid propellants under new AF contracts.

• GE unveiled its "tunnel" diode, in which electrons travel at the speed of light across the diode junction. The new diode works uniformly at temperatures between −4.2 and 600 F, and is unaffected by gamma rays or high levels of fast neutron irradiation. The device appears to have great potential in high-speed computers, satellite transmitters, and nuclear controls.

• Research on electronic devices for operation at cryogenic temperatures is moving ahead rapidly, with new devices reported every month. Two approaches are being used, one based on superconductivity of metals, and the other on ionization of impurities in germanium. For example, Arthur D. Little marked the completion of the second stage in its cryogenics research program to develop an extremely fast, low-cost computer with the announcement of workable vapor-deposited cryogenic circuits for electronic switches. Constructed of thin layers of lead, tin, and silicon monoxide, a circuit of 10 vapor-deposited cryotrons requires only a few micrograms of metal. ADL hopes to pack as many as 2000 of these cryotrons in a cubic inch.

• With its process for growing semiconductor crystals in flat ribbons at the thickness and finish required for use, Westinghouse Electric, under the previously reported $2 million AF contract, is now producing experimental "molectronic" space equipment, such as devices for reconnaissance, communications, telemetry, flight control, etc.

• Rocketdyne announced that it has developed a hydrogen-peroxide and hydrocarbon-fuel rocket engine for auxiliary boost of the Navy FJ-4 fighter aircraft. The booster engine proper, about 30 in. long and 16 in. wide, delivers 5400 lb of thrust. Rocketdyne expects procedures for installing and removing the engine and safe handling of propellants will have application in rocket engines for commercial aircraft designed to fly at Mach 5.

• GE has received a $390,000 eight-month NASA contract for studies on plug-nozzle rocket engines, which could conceivably increase low-altitude efficiency. In theory, the plug-nozzle concept "spikes" the conventional nozzle, with combustion taking place in a ring of cells around the rocket's base. Exhaust gases would follow the contour of the cone-shaped spike in leaving the combustion chamber and push away from the spiked surface depending on altitude. The idea is that the departure of gases would be self-adjusting according to altitude, thus increasing efficiency. Plug-nozzle advocates feel the concept could be best employed in boosters.

ELECTRONIC SURVEILLANCE

• More details of the vast scope of the U.S. use of electronic surveillance to gather intelligence data on Soviet activities are coming to light. Latest is Project Tepee, which uses the phenomenon of ionospheric backscatter to obtain information about man-made ionization—such as that produced by a distant nuclear explosion, or the exhaust column of a large ballistic missile launched thousands of miles away.

• Radio engineers have known about ionospheric backscatter for about 30 years. It occurs in high frequency radio signals (between 3 and 30 mc) which are capable of traveling long distances by repeatedly bouncing between the earth and the ionosphere as the wave front progresses from transmitter to distant receiver. During each bounce, a tiny fraction of the energy is transmitted back along the original path so that a sensitive receiver at the transmitter site can record on an oscilloscope each bounce. During experiments on radio propagation some years ago, for example, scientists at NBS regularly noticed a white glob on their oscilloscope when they transmitted across the continent. This was the extra backscatter produced by the upjutting Rocky Mountains which tended to block off a large proportion of the signal.

• William J. Thaler, 33-year-old scientist at ONR, set to work more than two years ago to put the phenomenon to good use. With $10,000 in funds and equipment borrowed from Patuxent River Naval Air Station, Thaler succeeded in proving the worth of his idea. Since then, his gear has detected the artificial ionization produced by U.S. nuclear tests last year in the Pacific and the South Atlantic, and missile launchings at Cape Canaveral. Similar equipment in the hands of one of the more clandestine government agencies has reportedly detected from within the U. S. a number of Soviet ballistic missile launchings.

• The great promise of Thaler's project (hence TP, which became Tepee) is that it can provide warning within a fraction of a second of any large-scale ballistic missile attack from Russia. This would assure a full 30-min attack warning, compared with 15 min from the huge 3500-mi-range radars of BMEWS. The latter, however, would still be necessary to provide the tracking data required by a positive anti-missile defense, such as Nike-Zeus.

• Thaler's project is still in the experimental stage and is probably several years away from becoming a true system, even if the Pentagon were to order full speed ahead. Such a decision would be necessary if blanket coverage of the Soviet is to be achieved with almost complete reliability. As things stand now, the U.S. apparently has several instruments focused on known Soviet launching sites—still far from covering the vast expanse of the U.S.S.R.

• Project Tepee is just one of many highly advanced electronic techniques the U.S. is using to study Soviet activities. The U.S. operates a large radar at Samsun, Turkey, to study Soviet missile activities, another in the Elburz Mountains north of Tehran, and probably still others in the Middle East. A radar has been hastily constructed in the Aleutians to follow ballistic missile re-entry in the Sea of Okhotsk. In addition to these "active" surveillance techniques, the U.S. is also conducting a great volume of "passive" surveillance, ranging from simple eavesdropping on Soviet communications frequencies to the colossal Sugar Grove, W. Va., radio telescope Navy is now building at a cost of $79 million.

MILITARY BUDGET

• Congress gave President Eisenhower a $39.2-billion military budget for fiscal 1960, only $20 million less than the amount sought by the Administration. Within the total, however, Congress made some drastic changes. The lawmakers were particularly active in juggling missile funds. They gave the Army an extra $137 million for Nike-Zeus and AF an additional $85 million as a down payment for eight more Atlas squadrons (bringing the total to 17) and an extra

$77 million to push development of Minuteman. On the other hand, Congress denied $127 million sought by AF for continued procurement of the Martin Mace air-breathing tactical missile. The upshot: AF will divert its "extra" ballistic missile funds for the Mace program and Congress can adjourn with the satisfaction that it has voted down "obsolete" weapons in favor of new systems.

• AF aircraft budget is in trouble, with emphasis on missiles resulting in wholesale slashing of allocations and a chance that production may be limited to as little as one fighter type, and only two bombers. Nuclear bomber is a likely casualty, unless AF can show the ship can be produced with a reasonable amount of funds in a relatively short time--an impossibility in the eyes of AF experts.

BALLOONS

• Not to be outdone in the space age is a small Minnesota balloon company developing a long-lived balloon capable of staying aloft for many months and perhaps becoming a sort of "in-atmosphere satellite." The Schjeldahl Co. of Northfield, Minn., has flight-tested a series of mylar "super-pressure" balloons capable of holding pre-set altitudes between 35,000 and 65,000 ft, regardless of temperature changes at dawn and dusk which force ordinary balloons to valve off helium or drop ballast.

• This raises the intriguing possibility of a balloon circling the earth several times on high-altitude jet streams during the course of its life. Powered by solar batteries and using miniaturized components sewed into its fabric, such a balloon could provide extremely valuable meteorological information. To date, Schjeldahl balloons have crossed the Atlantic on trips of several days duration, and are scheduled to be tried out for the Navy's transesonde program in Japan.

MAN IN SPACE

• Minneapolis-Honeywell's Aeronautical Div. will deliver a new two-man space cabin simulator to the AF School of Aviation Medicine, Brooks AFB, Tex., this month. The cabin, 8 ft high, 12 ft long and weighing 7 tons, will be used for a 30-day simulated space-flight. The two men who will take the "trip" will be selected from a carefully screened group of AF pilots, volunteers for the mission.

• Future space men may subsist on K rations in capsule form. Southwest Research Institute chemists have encapsulated corn oil, margarine, and chocolate in lab tests, using capsules with a low shell-to-filler material ratio, and feel it may be possible to make the capsule shell of an edible material which also has nutritive value. SRI scientists suggest a slot machine-like device to propel the capsules into the mouths of astronauts.

• NASA has named Western Electric prime contractor for the worldwide network of tracking and ground instrumentation stations for Project Mercury. The network, expected to cost $25 million by the time of its completion in 1960, will include radar and telemetry installations in Africa, the South Pacific, Cape Canaveral, Hawaii, Southern California, islands in both the Atlantic and Pacific, and on two ships. Bell Labs, IBM, Bendix, and Burns and Roe will be subcontractors for the project.

• Waltham Precision Instrument Co. is building the chronometric programer for Mercury. The device will record elapsed time from launch and automatically initiate 13 important functions, including re-entry.

MATERIALS

• Ryan Aeronautical, under an AF contract, is studying several metals in very thin gauges for a high-altitude research vehicle. Ryan's MinWat spot-welding technique will be used in the study.

• U.S. Chemical Milling Corp. announced that it has brought to practical use its Chem-Tol method for bringing tolerances of metal sheet to within ±0.001 in. The process, not chem-milling in the sense of using masks and etchants to produce a finished part, will be licensed to companies throughout the world.

• BuAer's award to Chromalloy Corp. of a substantial study contract on techniques for producing complicated metal shapes indicates increased Navy interest in explosive forming of refractory metals.

• Eastman Kodak's newly developed Irtran material—for missile and re-entry body infrared domes, prisms and flats—transmits, according to the company, more than 90 per cent of incident energy at 3 to 6 microns up to material temperature of 800 C. Microwave characteristics are close to those of natural mica.

• Dow Chemical will produce 5000 lb of polyphenyl ethers to be evaluated as high-temperature, radiation resistant lubricants by WADC.

INDUSTRY

• North American plans to acquire Phillips Petroleum's interest in Astrodyne and operate the now jointly-owned group as part of its Rocketdyne Div.. . . Raytheon dedicated its new Spencer Laboratory at Burlington, Mass., and announced that a 100-ft-long modulator will be built at the lab to test very high power microwave tubes. The lab will be devoted to the development of microwave tubes of all types with power levels never before attained. . . Du Pont's Baltimore plant will get a modern metallurgical research center to develop refractory metals for rockets, missiles, atomic power generators, and related hardware. Ready by fall of 1960, the facility will be capable of producing mill products—ingots, tubes, rod, sheet, strip, and foil. . . United Electrodynamics has acquired the electronics division of Rheem Mfg., including inventory, designs, and patents but not any of Rheem's plant or real property. . . Hazeltine Corp. has acquired Wheeler Labs as a wholly-owned subsidiary in a move to expand its systems engineering. . . Flanders Filters, which has just issued one of the few design handbooks on filtration of submicron particles from air, reports progress in lowering the resistance of absolute filters.

AMATEUR ROCKETRY

• Rep. David S. King (D., Utah) has introduced a bill (H.R. 8334) in the House to amend the NASA Act of 1958 "to encourage participation in amateur rocketry . . . by establishing facilities for study and experimentation in rocketry and related fields throughout the U. S." Rep. King estimated facilities could be built in every state for a total cost of less than $1 million and staffed and operated on an annual budget of less than $600,000.

• Kendall K. Hoyt of the Assn. of Missile & Rocket Industries has been named science adviser to the Washington wing of the Civil Air Patrol, with the aim of developing a pioneer unit of CAP cadets to study rocketry and space science.

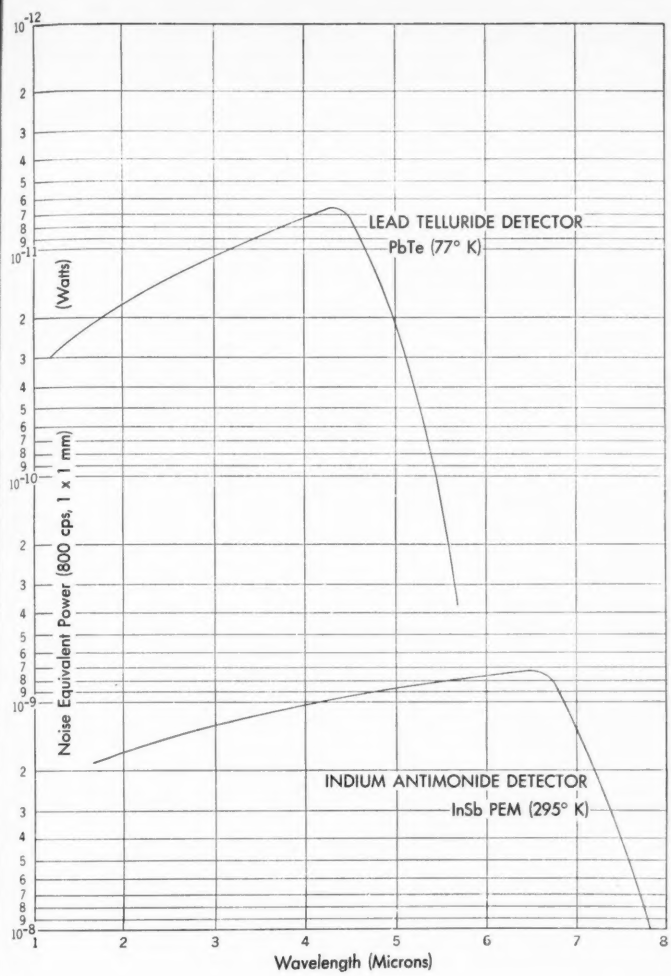
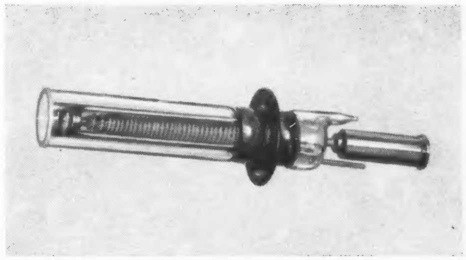


Chart above shows the spectral response of two Honeywell detectors—heart of infrared systems—described and pictured at right.

For further information on Honeywell infrared systems and components, call or write Honeywell, Military Products Group, Minneapolis, Minnesota.

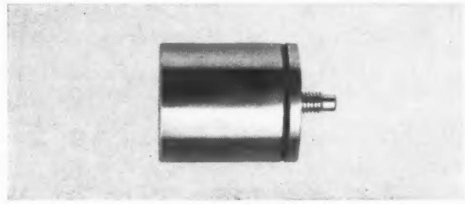
Honeywell

Military Products Group



Lead Telluride Detector—Honeywell's photoconductive lead telluride (PbTe) detector operating at the temperature of liquid nitrogen, 77° Kelvin, has its peak response at 4.3 microns. At this wavelength, a detector with a 1 mm^2 sensitive area is capable of detecting 7×10^{-12} watts with a signal-to-noise ratio of unity in a 1 cps bandwidth at 800 cps. The response time is no greater than 30 microseconds.

Cryogenics—Many sensors require cooling to low temperature for full effectiveness. Honeywell has designed a tiny cryostat which fits inside our own or other cells. When attached to a compressor or tank of nitrogen, it cools the cell to 77° Kelvin in less than two minutes. It has a diameter of .177 inch, a flow rate of two liters per minute at an input pressure of 2,000 psi and a heat exchanger one inch long. A small compressor system is being developed for spot cooling to 30° Kelvin.



Indium Antimonide Detector—Honeywell's indium antimonide photoelectromagnetic (InSb PEM) detector requires neither cooling nor bias supply. It is extremely fast, having a response time of less than 0.4 microseconds. Although it is less sensitive than the lead telluride detector to high temperature radiation, its noise equivalent power of 7×10^{-10} watts for a 1 mm^2 area at 6.6 microns with a 1 cps bandwidth indicates greater sensitivity to sources of radiation near room temperature. Its response frequency is independent of frequency out to several hundred kilo-cycles per second, making it of great value in wide band applications. It is finding wide application in situations demanding long wave-length response, rugged construction, and simplicity of operation.

For the record

The month's news in review

July 1—NASA announces plans to orbit atomic clock to test Einstein's Theory of Relativity.

—William M. Holaday is relieved as chief of DOD's guided missile office and made full-time chairman of Civilian-Military Space Liaison Committee.

July 2—Snark completes third 2000-mile round trip.

—AEC cancels two-year old nuclear study in which nuclear reaction was moderated by heavy water and core cooled by liquid sodium.

July 4—NASA Chief T. Keith Glennan warns that House space budget cuts could be crippling.

July 6—Soviet Union says it recovered alive two dogs and a rabbit launched into space on June 2 in a single-stage IRBM carrying a payload of more than 4400 lb.

July 9—House space committee sets inquiry into reports of sagging morale among Mercury Astronauts.

—DOD announces modified Titan first stage will be used for middle stage of the three-stage Saturn vehicle, with first firing set for 1960.

July 10—AF announces plans to install improved Azusa Mark II missile tracking system at Atlantic Missile Range next year.

—Navy plans to start Project Sunflare II on July 13, with 12 rocket firings scheduled.

—U.S., U.K., and Soviet scientists propose satellite police force to detect atom explosions in outer space.

July 13—U.S.S.R. claims it safely recovered two dogs sent into space in a single-stage IRBM with 4840-lb payload on June 10.

—ONR sends record-size plastic balloon to 139,500-ft altitude in Project Skyhook flight.

—AF reveals it is sponsoring Project Lunar Garden to help judge feasibility of a moon base.

July 15—Polaris test missile is destroyed in flight.

July 16—Army destructs Juno II shortly after takeoff.

—John H. Williams named new scientist member of AEC.

—Univ. of California's Lick Observatory dedicates 120-in. reflector telescope.

July 17—Second stage of Nike-Asp fails to ignite after reaching 90,000 ft in Navy Project Sunflare shot.

July 18—AF successfully ground-tests Titan ICBM.
—Navy Corvus missile is successfully tested.

July 21—AF Atlas completes 5500-mile test flight.

—U.S. and U.S.S.R. agree on extensive exchange of scientists.

July 23—NASA says Mercury Astronauts will wear \$3750 space suits—modified pressure suit made for Navy by B. F. Goodrich and air-conditioned underwear made for AF.

—Boeing 707-321 flies to Moscow in record 8 hr 53 min.

July 24—AF Thor reaches 300-mile altitude, where camera in nose cone photographs curvature of earth and sun.

July 26—Defense Secretary McElroy indicates U.S.S.R. might be ahead in race to produce first operational ICBM.

—Navy announces development of quieter and more reliable nuclear sub powerplant, known as the natural-circulation pressurized water reactor.

July 27—NASA announces plans to launch paddle-wheel satellite Aug 7.

July 28—Lt. Gen. Bernard A. Schriever, AF ARDC Chief, tells Congress Atlas should be combat ready by Sept. 1.

—AF says Thor nose cone launched July 24 achieved first stabilized, nontumbling flight recorded.

July 30—Maj. Gen. Donald J. Keirn, in charge of the on-again-off-again atomic plane project, announces his retirement from military service on Aug. 31.

—Senate committee restores \$68.2 million to space budget.

July 31—NASA announces plans to soft-land a lunar seismograph.

Rehearsal for Man in Space

AF dummy is rigged for space tests using miniaturized instruments developed by Boeing's Seattle Div. Except for metabolism recorder held by Boeing engineer, all data recording devices attached to dummy are smaller than a wrist watch. A thermistor, smaller than the head of a pin, replaces a rectal thermometer and is worn inside the ear. Other instruments are attached to the ear lobe or strapped around the wrist, leg, elbow, and chest of the dummy. The metabolism recorder was trimmed down from a 100-lb unit to 15-lb unit shown.

COVER: *Dramatic Edwards AFB photo shows Atlas ICBM rising into position for captive testing on Test Stand 1A at the Missile Captive Test Site location at ARDC's AF Flight Test Center at Edwards.*

Astronautics

SEPTEMBER 1959

ARS-AAS Merger Negotiations Suspended

Early in January, officers of the American Astronautical Society approached the ARS President regarding the advantages of a merger of the two societies. Informal talks resulted in a series of meetings of negotiating committees appointed by the Boards of the respective societies in San Diego in June, during which the ARS Negotiating Committee strove to accept as many as possible of the terms put forward by the AAS negotiators in the belief that the cause of astronautics could best be served through the unification of two societies with such similar aims.

In order to make it possible to submit terms of the proposed merger to the membership of both societies during their fall elections, a joint meeting of the Boards was scheduled during the AAS western national meeting in Los Angeles on Aug. 4.

On the evening of Aug. 3, the AAS Board met and passed a resolution which was handed to the ARS Negotiating Committee at a breakfast meeting the next morning. The resolution begins:

"The basic motivation in considering a merger of ARS and AAS has been to establish a National Society that would better serve the Astronautical Sciences in the U.S.A. and the world. We feel that this aim is best served by a society dedicated solely to the advancement of the astronautical sciences. We, therefore, conclude that further discussions of an AAS-ARS merger are not warranted. . ."

Obviously, the unilateral action of the AAS Board resulting in this resolution speaks for itself.

John P. Stapp
President, American Rocket Society

Nova—A manned lunar rocket

Direct flight to the moon, landing, and return to earth of a two-man 8000-lb space capsule will be possible with rocket engines emerging from development within the next few years

By Milton W. Rosen and F. C. Schwenk

NATL. AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, D.C.

Background

Nova, the most ambitious project in NASA's rocket vehicle development program, envisages the clustering of as many as six engines in the 1- to 1.5-million-lb-thrust class to provide a first-stage booster with a total thrust of over 6 million lb—enough to launch a manned vehicle directly to the moon for lunar exploration and subsequent return to earth.

NASA rocket development programs are gaining momentum with each sign of success. Rocketdyne has already reported the successful static firing of a developmental version of the million-lb engine to its rated thrust level, while Pratt and Whitney's progress with a liquid-hydrogen engine for Project Centaur has also been rapid.

Vehicle development becomes the next major step to implement mission and design decisions. It takes a minimum of three years of solid engineering and testing to produce a prototype of a major vehicle in the Nova class. This means decisions as to its staging and payloads must be made in the very near future to make a Nova vehicle a reality by 1965.

This article by Milton W. Rosen, head of NASA's Rocket Vehicle Development Program, and F. C. Schwenk, based on a paper presented at the 10th International Astronautical Congress in London, Aug. 31–Sept. 5, gives the first extensive analysis of how the Nova project might develop in terms of a complete vehicle for space exploration. The opinions expressed are those of the authors, and do not necessarily reflect the views of NASA. However, the design discussed here clearly reflects what appears in the offing in other NASA vehicle programs, such as Project Centaur, and the NASA concept of manned space capsules, as seen in Project Mercury.

The vehicle described here is, as the authors note, still in the preliminary design stage. However, it may well provide a picture of the vehicle which will some day put a U.S. astronaut on the moon.

WE ARE on a Pacific Island some five to ten years in the future. The latest of a series of Nova rockets stands erect in the launching area. Only a few men can be seen working on the rocket, in contrast to the hundreds that used to crowd the launch areas of the late '50's, for we have learned to make our rockets less complicated and more reliable as they have increased in size. No battery of speakers blares out the countdown. Instead, each worker has a small transceiver attached to his helmet through which he receives the countdown and communicates with the blockhouse.

Finally the 300-ft-high gantry rolls away and the rocket stands alone, poised for launching. Six giant motors ignite in pairs while the rocket is held fast to the launch stand. Finally, the umbilical cables drop away and the rocket rises with the roar of 9 million lb of thrust. The light of the exhaust illuminates the entire island.

The rocket rises vertically for 10 sec and then tilts slightly to the east. It continues to burn for 135 sec as it rises to an altitude of 35 mi. Then it cuts off and separates to be recovered for later use. The second stage ignites immediately and burns for 177 sec, accelerating to a speed of 15,800 fps. Finally, the third stage fires almost parallel to the earth's surface at an altitude of about 150 mi.

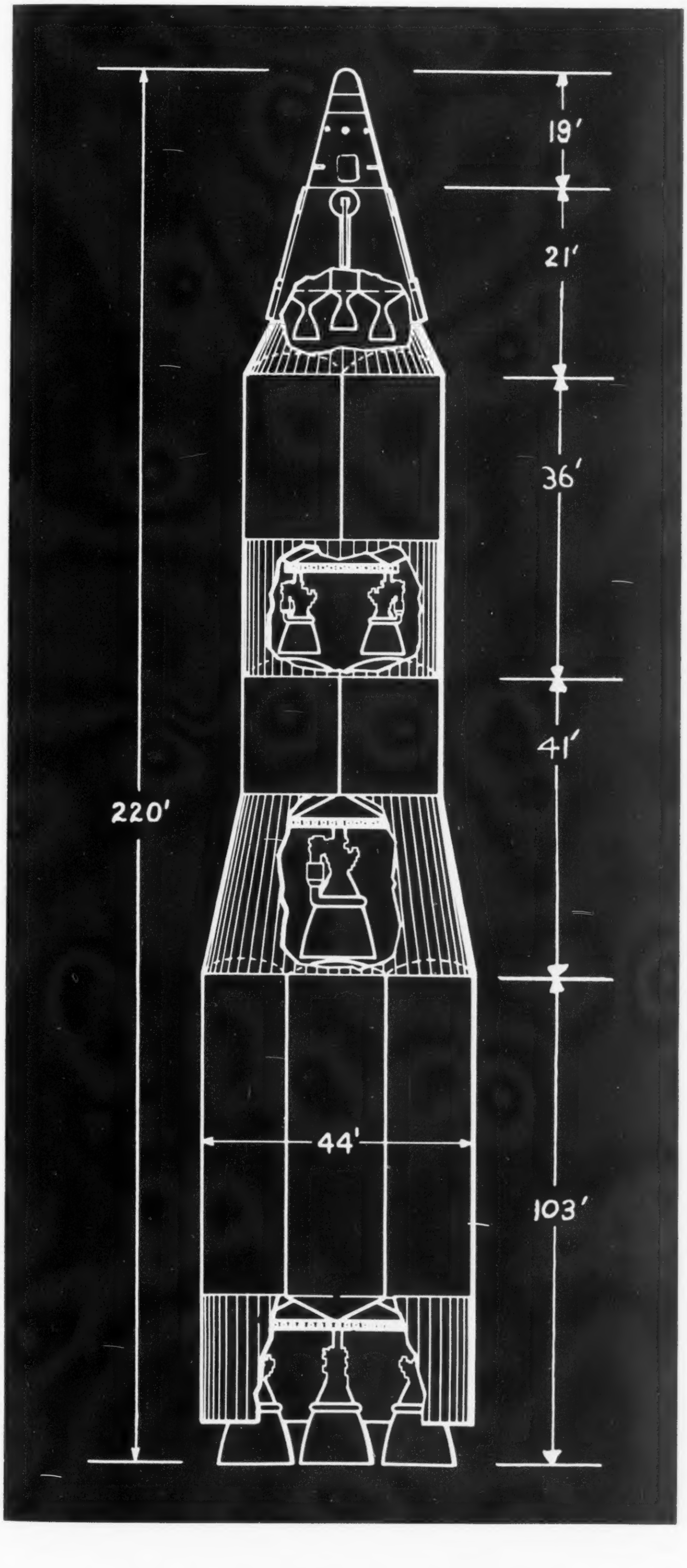
Through Cislunar Space

After third-stage burnout, the cone-shaped vehicle coasts silently through cislunar space for 60 hr. As it approaches the moon, the vehicle starts to turn under the influence of control jets to orient itself for descent to the lunar surface. Four braking rockets fire, maneuvering the vehicle toward the selected landing area. Landing struts extend from the side of the cone, spanning 40 ft. The cone settles down slowly and comes to rest on the moon.

As the two occupants emerge, they see 500 yd away an exact duplicate of the vehicle that brought them to the moon. This spare return vehicle had been sent up one month earlier, landed on the moon, checked itself out, and radioed its state of readiness to earth. Farther away is the radio beacon sent to the moon a year earlier on a Centaur rocket to mark the landing area.

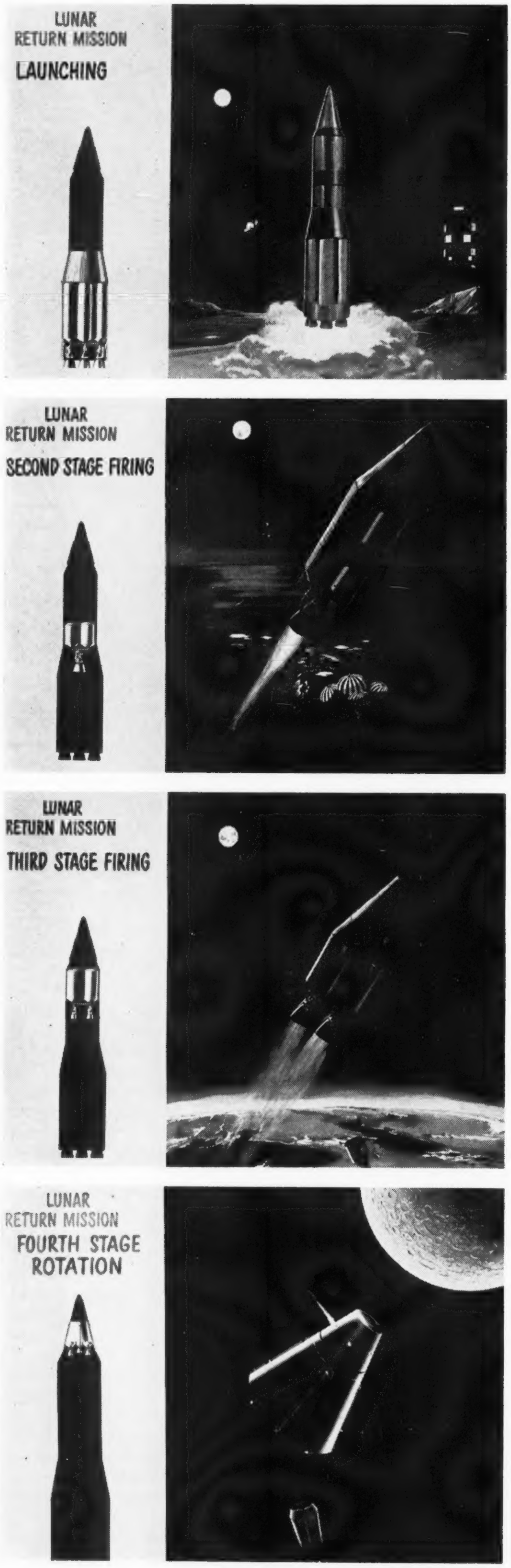
How the two men occupy themselves during their 12 days on the moon can be better described by those who for years speculated about the lunar crust.

Nova—Direct-Flight Lunar Return Vehicle



Weight Breakdown

Stage 5 (Return Rocket)	
Gross	36,000 lb
Burnout	13,700 lb
Propulsion Tanks	3800 lb
Returned to Earth	8000 lb
Stage 4 (Landing Rocket)	
Gross	102,000 lb
Burnout (On Moon)	49,100 lb
Propulsion, Tanks, Landing Gear	13,100 lb
Payload on Moon	36,000 lb
Stage 3	
Gross	600,000 lb
Burnout	146,000 lb
Stage	498,000 lb
Stage 2	
Gross	1,700,000 lb
Burnout	678,000 lb
Stage	1,100,000 lb
Stage 1	
Launch	6,700,000 lb
Burnout	2,000,000 lb
Stage	5,000,000 lb



When they are ready to depart, the men re-enter the capsule and fire the fifth stage, which uses the fourth stage as a launching stand. The final stage burns for 220 sec. Then starts the long 60-hr return trip, during which a few precisely timed corrective blasts put the cone in the correct corridor for re-entry to the earth's atmosphere. Then the fifth-stage motor is discarded and the cone begins its descent with careful control of its angle of attack. The cone approaches the earth, its ablative surface glowing from the heat of re-entry. At 30,000 ft, a large parachute is deployed which slowly lowers the capsule to the ocean.

The foregoing is the type of mission NASA is working on in Project Nova. Let us go a little deeper into the design decisions for such a vehicle in terms of propulsion, for propulsion technology sets the pace for the Nova project, perhaps more so than for many of the other space exploration vehicles under development by NASA.

One of the major concerns in any large vehicle of this kind, capable of direct, rather than rendezvous, flight to the moon, is the selection of propellants for the various stages. High-energy propellants—for example, liquid oxygen and liquid hydrogen—are most desirable to achieve the mission with the least vehicle gross weight. Naturally, this propellant combination can only be used if the necessary engines are available and if the techniques for handling liquid hydrogen are developed. We believe that both these conditions can be met in the smaller stages. Consequently, we see high-energy propellants for the third and fourth stages of the vehicle.

For a return capsule weight between 8000 and 9000 lb, we can show that the vehicle at liftoff must weigh more than 4 million lb. A sea-level thrust rating of over 6 million lb is therefore a necessity. NASA is presently developing a rocket engine capable of producing $1^1/_2$ million lb of thrust with liquid oxygen and kerosene propellants in the Nova program. A cluster of several of these kerosene-lox engines is therefore the logical choice for first-stage propulsion.

Now we must decide on the propellants for the second stage.

The performance advantage afforded by high-energy propellants is obvious: A 6-million-lb-thrust first stage with high-energy propellant in the second stage can provide the same payload capability as a

Panels on these two pages show the entire manned lunar return mission. On this page, starting at top, Nova launching; firing of second stage, with jettisoned recoverable first stage at bottom center; third-stage firing, with jettisoned second stage falling back to earth; and fourth-stage rotation, carried out during approach to moon by means of control jets.

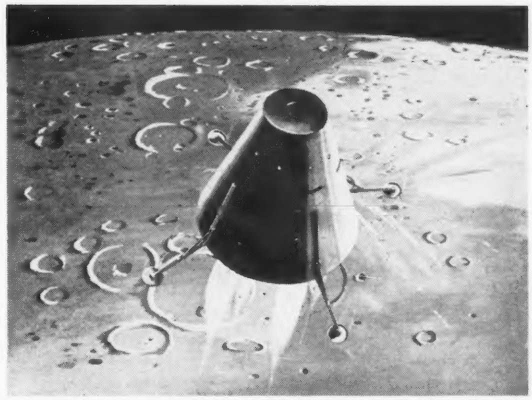
vehicle having a takeoff thrust of 9 million lb and lox-kerosene in the second stage. However, our calculations also show that a second-stage thrust level of 2.4 million lb is required in the vehicle using the high-energy propellants. Such a thrust level in a high-energy engine may not be available for a long time to come. Hence, our choice at this time is the conventional lox-kerosene second stage using one large engine.

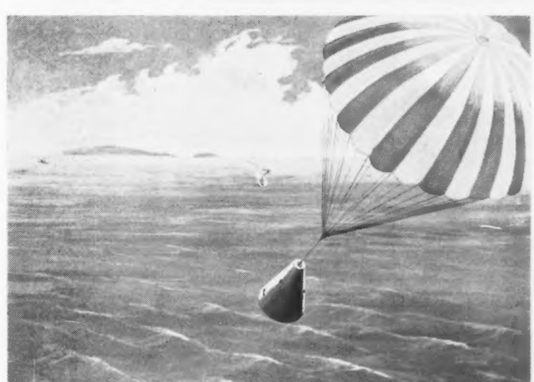
Liquid hydrogen might possibly be stored long enough on the surface of the moon to allow its use for launching from the lunar surface. There is an impressive increase in payload (or reduction in first-stage thrust for the same payload) if high-energy propellants are employed in the lunar launch. In this situation, the term "conventional propellants" refers to those that are liquids at normal temperatures and pressures, such as nitrogen tetroxide and hydrazine.

Propellant Storage

A fundamental question confronts us: Which propellants can be stored in the vehicle tanks on the moon, where surface temperature varies, in the extreme, from −150 to +134 C? There is a strong possibility that, with careful vehicle design and proper shielding against thermal radiation, high-energy propellants such as liquid oxygen and liquid hydrogen can be stored as well as any in the lunar environment. However, this is an area that has not yet been explored, and we choose at this time the more conservative propellant combination.

We have assumed that the return vehicle, or manned capsule, enters the atmosphere at hyperbolic velocities. Of course, a powered sixth stage could be employed to first slow the vehicle to orbital speed. In this case, the landing would be similar to that of NASA's Project Mercury. The graph on page 96 shows what a retro-to-earth orbit costs. For a capsule payload weighing 6000 lb, 24 million lb of thrust at launch (16 engines) is required if we must provide propulsion to place the capsule in orbit on the return trip; and, actually, a capsule weight of 8000 lb is desired. Clearly, retro-to-orbit is a costly maneuver, and its use would require a vehicle so large as to make the task of a manned lunar landing (CONTINUED ON PAGE 96)





This sequence shows (top to bottom) the capsule's descent to the lunar surface as braking rockets fire; exploration of the moon by two-man crew, with spare return vehicle, landed earlier, in background; fifth stage taking off from the moon, leaving behind the fourth stage; and, finally, return to earth and recovery at sea of 8000-lb capsule.

Space propulsion system profiles

Schemes for such systems are many and diverse, yet all seem to deserve consideration . . . Better power efficiency appears to be the real challenge in propulsion system design

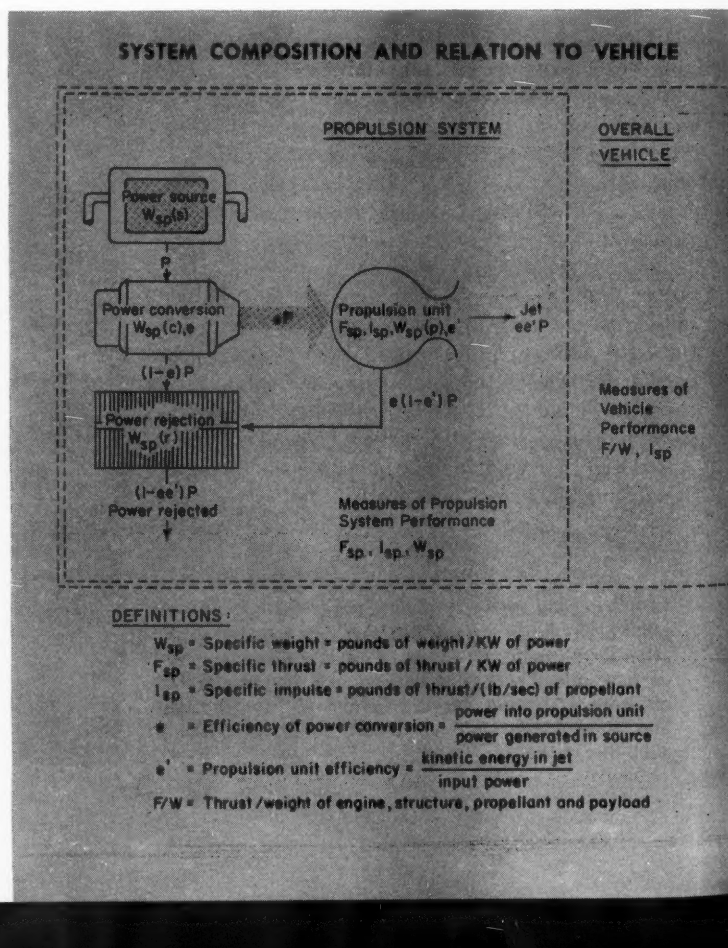
By William R. Corliss

GENERAL ELECTRIC CO., CINCINNATI, OHIO

LIKE any other engine, the space propulsion system is only part of a larger entity–spaceship, satellite, or probe. The propulsion system provides its vehicle with appropriate thrust and specific impulse to perform an assigned mission satisfactorily. Vehicle performance may be expressed by thrust/weight ratio, which defines the acceleration limit of the vehicle, and specific impulse, which indicates the propulsion unit's propellant economy.

But the performance of a space propulsion system cannot be described completely by numbers. Performance may also be said to include many nonnumerical factors, the most important of which are:

William R. Corliss is a space systems specialist at GE's Flight Propulsion Lab Dept. He received a B.S. in physics from Rensselaer Polytechnic Institute in 1950, and an M.S. in physics from the Univ. of Colorado in 1953, the intervening time seeing him also employed by the Univ. of California Radiation Lab and the Central Radio Propagation Lab of the Bureau of Standards. Before joining GE in 1956, he worked on the Aircraft Nuclear Propulsion Project at Pratt and Whitney.



Reliability—Probability that equipment will function satisfactorily throughout the mission.

Vulnerability—Probability that the system will not survive in the space environment during the mission.

State of the art—When the system will be operational.

Growth potential—How much the system can be improved both in performance and the ability to do new jobs.

Development risk—Proportional to the probability of encountering insoluble development problems.

The figure on the opposite page shows the composition of the space propulsion system. There must be an energy source, energy conversion equipment, a waste-heat rejector, and the propulsion unit itself. Power originates in the source and flows to the other components as indicated. To describe adequately the four separate components of the propulsion system, it is necessary first to evolve factors directly related to those which describe the performance of the vehicle. The figure also gives these measures and defines them.

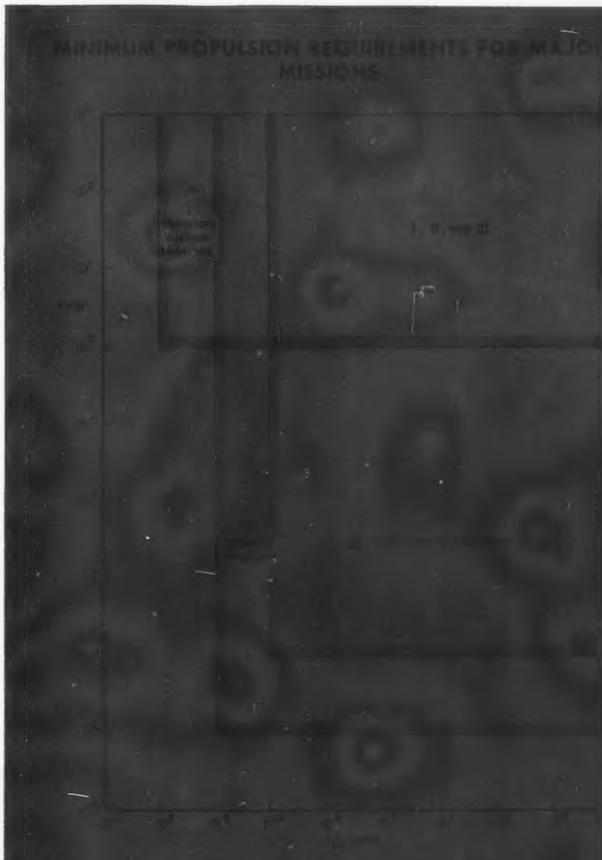
Mission requirements determine the size and constituents of both the space vehicle and its associated propulsion system. For simplicity, the variables describing the mission should be closely related to the performance factors which give the capabilities of the vehicle. For most space missions, it is possible to estimate minimum performance requirements in terms of the same parameters used to describe vehicle performance—thrust/weight ratio and specific impulse. Direct comparisons between mission and vehicle are thus possible.

Three Classes of Space Mission

There are three broad classes of space missions, which the table on page 26 describes. Estimates of the minimum performance required by these mission classes are given in the figure at top right. Obviously, all missions are best accomplished by a propulsion system with high thrust/weight ratio and high specific impulse. Such an "ideal" propulsion system, of course, does not exist.

Using the coordinates in the top figure right, we can plot the calculated capabilities of some presently conceived space propulsion systems, which is done in the bottom figure on this page. Although nominal allowances are made for payload, propellant, and structural weights, the regions outlined in the F/W-I_{sp} plane should be regarded as approximate only. Still, an assessment of the propulsion systems and their possible applications may be obtained by superimposing the top and bottom figures on this page.

The bottom figure on this page shows that there



is a large gap between the nuclear and chemical rockets and the more advanced space propulsion concepts. This gap occurs because two basically different kinds of reaction engines are represented. Chemical and nuclear rockets accelerate mass to exhaust velocity by combustion or nuclear heat-addition and subsequent expansion through a nozzle. These systems are extremely light and fairly efficient but have low specific impulses. On the other hand, electrical engines depend on high-grade electrical energy for the electrostatic or electromagnetic acceleration of mass. The generation of this electrical power requires heavy equipment, which may have low conversion efficiency. Heavy generating equipment significantly reduces the thrust/weight ratio of electrical space engines.

There is also a falling off of thrust/weight ratio with specific impulse. The basic equations involved are shown below. The inverse proportionality of F/W_p and I_{sp} does not include the contribution of payload, propellant, and over-all structure. It does, however, serve to focus attention on the rapidly increasing power demanded by high specific impulse machines. When power is proportional to power supply weight, the F/W_p ratio suffers from the increased sizes of source and conversion equipment and the larger heat radiators required.

The power supply, including fuel, is an integral part of the space propulsion system. The weight of

BASIC EQUATIONS

$$F = \frac{\dot{w}v}{g_0} \qquad P = \frac{\dot{w}v^2}{2g_0} \qquad I_{sp} = \frac{v}{g_0}$$

If $W_p \propto P$ then: $F/W_p \propto 1/I_{sp}$

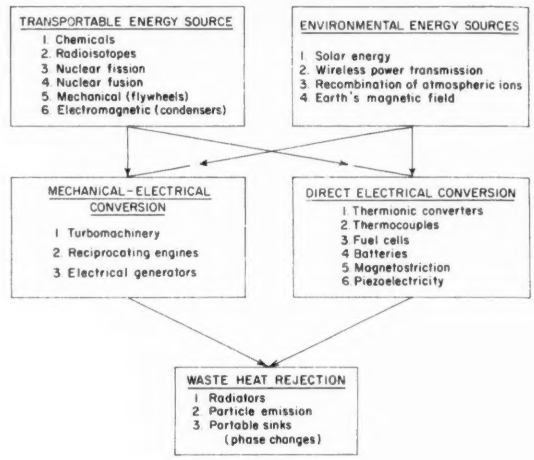
where: F = thrust (lb)
v = exhaust velocity (ft/sec)
P = power (ft-lb/sec)
W_p = weight of propulsion system alone (lb)
$\dot{w}$ = weight flow (lb/sec)
g_0 = 32.2 ft/sec²
I_{sp} = specific impulse (sec)

MISSION CLASSES

Class	Purpose	Minimum Requirements
Planetary surface	Launching satellites, probes, spaceships, ICBM's	$F/W > 1$ $I_{sp} > 100$
Satellite	Orbit changing and trimming, making up drag losses, attitude control	$F/W > 10^{-5}$ $I_{sp} > 1000$
Interplanetary-Interstellar*	Travel to the moon, planets, and stars (orbit to orbit)	$F/W > 10^{-4}$ $I_{sp} > 10{,}000$

* Minimum requirements for this class vary significantly with time allotted for the mission. Estimates are order of magnitude only.

CONSTITUENTS OF ELECTRICAL POWER SUPPLY



the power supply usually controls the denominator in the F/W ratio. A host of different power supplies are available. The figure above attempts to categorize some of them, which might be used in any combination. It is possible to plot the specific weights (pounds of weight per kilowatt of power) and efficiencies of all components, but this procedure is complicated by the fact that the specific weights of the heat sources are frequently sensitive to the mission length and the power level. Contrasting examples of these effects are gasoline engines and nuclear reactors. For survey purposes, it is more convenient to indicate the rough ranges of specific weights that are currently being calculated: Thermal systems (for rockets) show 0.05 to 0.5 lb/kw, and electrical systems (for ion drives) 5 to 50 lb/kw.

Reduce Specific Weights

Clearly much of the effort in space propulsion must be spent in reducing the high specific weights of electrical power supplies. Direct conversion and solar power do not present ready solutions to the weight problem. In contemporary direct-conversion power supplies of more than 10 kw capacity, a heat-transfer fluid must be included to convey waste heat to the radiator. In such powerplants, only the electrical generator itself will be replaced by a static part. The pump or compressor, the radiator, and the heat sources are still present. In the case of solar power, the source of specific weight must include the weight of the large collector, meteoroid shields, and supports.

It has become apparent that, with currently en-

visaged technology, there is no combination of power supply components that will allow over-all specific weights much below 10 lb/kw for electrical powerplants. Ten years from now, direct conversion, metal-vapor cycles, and other advanced developments will bring values as low as 5 lb/kw.

The propulsion unit is the distinctive part of the propulsion system. The power supply may be used for auxiliary power and other purposes, but the propulsion unit has only one task, to provide thrust. Its contribution to the system performance is usually through the specific thrust term (pounds of thrust per kilowatt of power) which factors in efficiency in its usual definition. The contribution to the weight of the system is usually small in comparison with the power supply. The propulsion unit also determines the specific impulse.

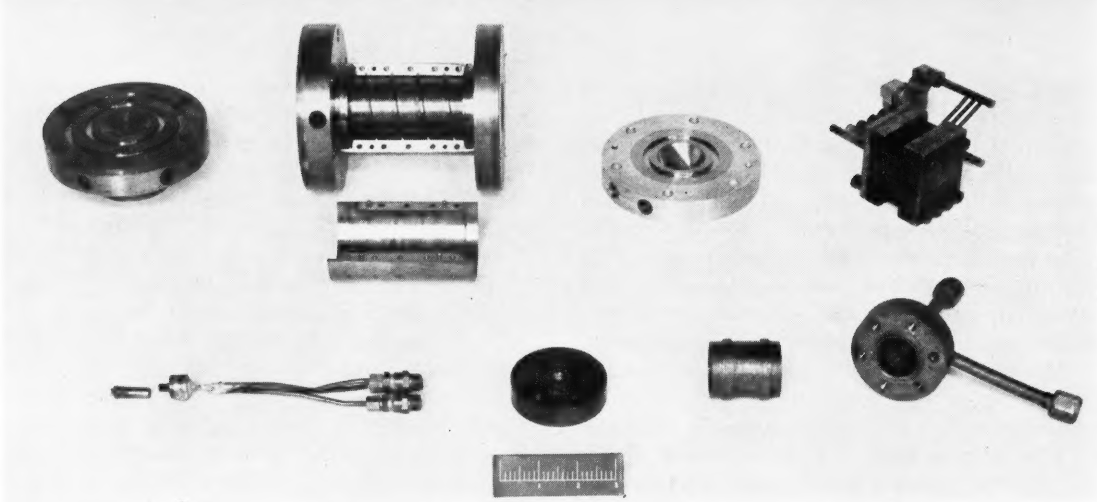
Space propulsion units take diverse forms. The table below gives major characteristics, typical system performances and some possible applications of seven of the more important types of propulsion unit. Note that there seem to be applications for all of the systems listed. This indicates that the spectrum of contemplated space missions is very broad and that, although some missions are definitely more important than others, there is no incontrovertible reason for eliminating any of the systems listed. It is also evident that there is no propulsion system which is "best" as yet, although there may be one system which meets the needs of a particular mission best.

The real challenges in propulsion unit design lie in the area of better power efficiency ($\acute{e}$). Since some projected efficiencies already approach 100 per cent, there is not too much room for improvement here for many systems. Reliability is a critical factor with missions being planned for several years duration. A clear opportunity for improvement lies in the design of a system with both thrust and specific impulse modulated, allowing it to perform different missions.

A review of some of the proposed space power supplies and propulsion units seems to show that progress toward the "ideal" system with high F/W and I_{sp} depends heavily on the development of lighter and more efficient power supplies, and, to a lesser extent, more efficient propulsion units. Concurrent improvements in reliability, vulnerability, and the other qualitative parameters are also desirable, particularly for long missions.

TYPICAL PROPULSION UNITS

Type	Characteristics	Barrier Problems	Typical Performance	Applications
Chemical Rockets	Converts chemical energy into exhaust kinetic energy by heating combustion gases and expanding them through a nozzle.	Limited by lack of high-temperature materials, the low energy of the chemical bond, and the high molecular weight of combustion gases.	$F/W = 2 \times 10^{0}$ $I_{sp} = 300$ sec	Planetary surface missions.
Nuclear-Fission Rocket	Converts nuclear-fission energy into exhaust kinetic energy by heating a propellant in a nuclear reactor and expanding it through a nozzle	Limited by the lack of high-temperature materials, nuclear hazards, and lack of easily stored and handled, low-molecular-weight propellants.	$F/W = 2 \times 10^{0}$ $I_{sp} = 800$ sec	Planetary surface missions.
Plasma Jet	Converts the energy in an electric arc into the kinetic energy of a propellant which forms a constricting vortex about the arc. The fluid vortex cools the engine structure and confines the arc, allowing temperatures approaching 100,000 F to be reached.	Erosion of nozzle and orifice by hot propellant. The lack of easily handled and stored, low-molecular-weight propellants.	$F/W = 10^{-3}$ $I_{sp} = 1000$ sec	Satellite missions, probes, and slow interplanetary missions.
Magnetohydrodynamic	Magnetic pressures generated by plasma currents are used to accelerate plasma.	Low efficiencies, low-weight flows.	$F/W = 10^{-4}$ $I_{sp} = 10{,}000$ sec	Satellite missions, probes, and slow interplanetary missions.
Ion Drive	Uses electrostatic fields to accelerate charged particles. Require ion source and beam neutralizer.	Space charge limitations on current source areas and space charge neutralizers; electrical breakdown across propellant in accelerator.	$F/W = 10^{-4}$ $I_{sp} = 10{,}000$ sec	Satellite missions, probes, and slow interplanetary missions.
Photon Drive	Obtains thrust from the momentum carried off by photons emitted by heated objects like filaments and radiator pipes or by nuclearly generated electromagnetic radiation.	Excessive power requirements for reasonable thrusts (7.4×10^{-7} lb/kw). Large radiating areas required.	$F/W = 10^{-6}$ $I_{sp} = 30{,}000{,}000$ sec	Probes, slow interplanetary missions.
Solar Sail	Uses light pressure to obtain thrust.	Tremendous areas needed to obtain significant thrusts (10^{-7} lb/ft^2).	$F/W = 10^{-4}$ $I_{sp} =$ infinity	Satellite missions, probes, and slow interplanetary missions.



Typical laboratory rocket motors. Thrust range is from 1.5 oz to 10 lb. Special features include slit-type exhaust nozzles, cooling jacket design to allow sampling probes inside the combustion chamber, and combustion chamber and supersonic nozzle electroformed as a single unit.

Laboratory and nonthrust rockets

In one sense a tool for producing controlled high heat flux, small motors now appear ready for a spurt of nonthrust applications in the lab and industry

By A. E. Weller

BATTELLE MEMORIAL INSTITUTE, COLUMBUS, OHIO

A. E. Weller is a senior chemical engineer in the Aeronautics and Thermodynamics Division of Battelle Memorial Institute. Since 1949, he has been associated with applications of rocket motors as research tools in studies of combustion, heat transfer, and materials development. He received a B.S. in chemical engineering from Northwestern Univ. in 1951.

IN VIEW of the trend toward ever larger rocket engines for flight propulsion purposes, it is worthwhile to remember the opposite end of the scale where thrusts may be as small as ounces and where the windowshaking roar dwindles to a mere whistle. Although laboratory and nonthrust rockets are not restricted to such small units, it is in this field that small rocket engines are beginning to achieve considerable importance.

For approximately 40 years, the development of rocket motors for flight propulsion has been in process, culminating in the enormous military development and production programs now underway. On the other hand, the development of nonthrust applications of rocket motors has a history of barely 10 years, although not because the necessary technology was lacking. The propulsion developments have supplied technology in such abundance that years may be required to disseminate and digest the mountains of information accumulated.

Industrial technology does not generally advance in discontinuous jumps. "Breakthroughs," in the true sense of this term, are the exception rather than the rule. Rather, new technology is built on past technology and the two are connected inseparably with economics. The rising standard of living is both the result and the cause of technological advancement.

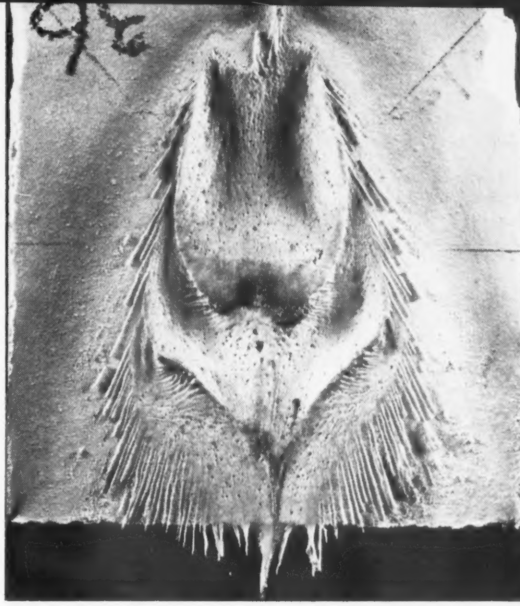
The development of industrial nonthrust applications for rocket motors is not expected from the consideration of interrelated technological and economic factors. Although the necessary technology may be available, it appears that we are just entering the period when economic factors will justify such applications. In view of the available background of information derived from propulsion developments, accelerated progress in nonthrust applications of rocket motors is considered likely during the next few years.

Just what does the rocket jet offer as a tool? Basically a rocket engine is a device which produces a high-velocity stream of hot gases. Temperatures in the range of 5000–6000 F are common and velocities upward to 8000 fps can readily be obtained. In addition to the use of this gas stream to produce thrust, the characteristics of the exhaust jet suggest other possible uses of rocket engines. In particular, the high temperatures and velocities allow heat-transfer rates which may be enormous compared to those encountered in conventional heat-transfer equipment. Although this characteristic has been the bane of the rocket engineer, causing uncountable burnouts, it has proved the basis of nearly all of the laboratory and nonthrust applications of rocket engines up to the present time.

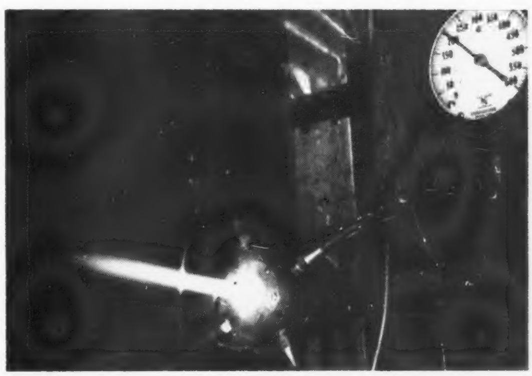
Used in Testing Materials

High-temperature materials testing and development, based on exposing the materials to the exhaust jet of a rocket motor, has attained extensive proportions. The commercial use of rocket engines in the Jet Piercer, now well developed, depends on the rapid heat transfer obtainable from a rocket exhaust. Additionally, the use of a rocket exhaust has been seriously considered for the flame-hardening of steels. The rapid heat transfer allows very thin, hard cases to be obtained with a minimum consumption of fuel and distortion of the base metal.

In the field of heat-transfer applications, the normal concepts of rocket performance, based on propulsion applications, must be revised. To develop the highest heat-transfer rates, high gas enthalpy and high mass velocity are required. A general performance parameter for heat transfer to cold surfaces can be derived from heat-transfer equations as the product of the temperature, specific heat, density, and velocity of the jet, $TC_p\rho V$. With standard analytical techniques, this parameter can be transformed to be approximately the product of chamber pressure and gas enthalpy divided by the specific impulse, $P_c\Delta H/I_{sp}$, or more exactly, $P_c\Delta H \sqrt{M/T}$, where M is the molecular weight of the gas. Thus, in contrast to the usual case of



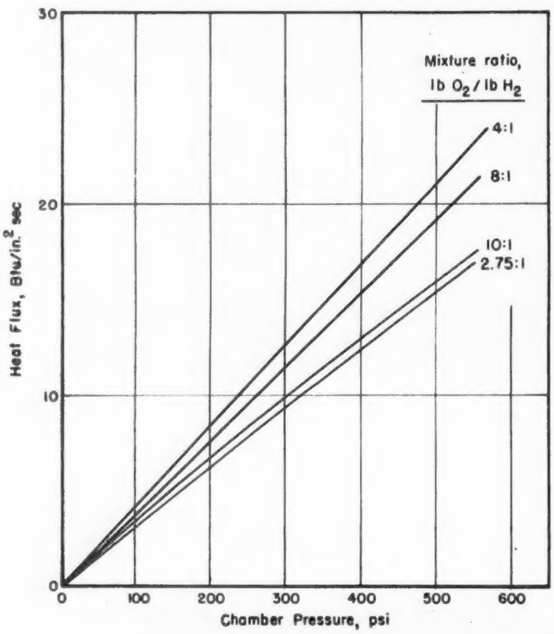
Effect of rocket exhaust on heat-resisting ceramic. High temperature and heat flux have caused ceramic to melt and flow along surface. Solidified streamers indicate direction of flow is at right angles to gas stream in some places. Wave-like appearance of surface is evidently caused by detachment and reattachment of jet. Reverse flow at stagnation point is clearly visible.



Small laboratory rocket motor for evaluating nozzle material. Wide operating ranges in chamber pressure, mixture ratio, and nozzle heat flux allow this motor to simulate environment found in many large propulsion systems.

This control panel and instrumentation operates an oxygen-hydrogen rocket motor used in evaluating heat-resisting materials. Interlocked controls and a deadman switch minimize the possibility of malfunction due to human error.

Small O_2-H_2 Rocket Heat Fluxes



In contrast to what theory predicts, maximum heat flux occurs with a mixture ratio of 4:1 rather than 8:1. Heat flux is a function of injector design and combustion chamber volume.

Heat-Transfer Performance Parameters for Various Propellant Combinations

Propellants	Mixture ratio, lb oxidizer/lb fuel	Specific impulse,* sec	Heat transfer parameter, $\Delta H \sqrt{\frac{M}{T}} \left(\frac{\text{Btu}}{\text{lb}} \sqrt{\frac{\text{lb}}{\text{Mole R}}} \right)$
Combustion Systems			
O_2-H_2	8 : 1	310	291
O_2-H_2	4 : 1	360	220
F_2-H_2	19 : 1	340	258
F_2-H_2	4.5 : 1	375	200
O_2-gasoline	3.65 : 1	245	273
O_2-gasoline	2.5 : 1	260	244
O_2-C_2N_2	0.615 : 1	—	150
Other Devices			
Heated H_2, 3500 F (such as nuclear rocket)			298
H_2O Plasma jet, extrapolated to a chamber pressure of 500 psi			1000
H_2O Plasma jet, chamber pressure of 30 psi, the present limit of most such devices			60

* Based on a chamber pressure of 500 psi

rocket engines as thrust devices, for heat-transfer applications the specific impulse should not necessarily be maximized.

The table below left gives the heat-transfer parameter for a number of propellant combinations and devices. The most suitable mixture ratios tend to be near stoichiometric, where the enthalpy per unit mass is a maximum and the molecular weight is high.

As the temperature of the surface receiving the heat is increased, the performance parameter decreases. However, it decreases more rapidly for some propellant combinations than for others. Surprisingly, the cyanogen-oxygen combination, in spite of its high flame temperature, yields a very low performance parameter. Until the heat-receiving surface has reached quite high temperatures, O_2-H_2 flames are capable of appreciably higher heat-transfer rates than the O_2-cyanogen flame.

No Systematic Investigation Made

No completely systematic investigation of all of the effects known to influence the heat transfer from a rocket jet to a heat receiver appear to have been made. For example, while heat-transfer theory predicts that the maximum heat transfer should be obtained from a jet expanded in a simple converging or Mach 1 nozzle, some data indicate that a 25 per cent greater heat-transfer rate can be obtained by expanding the jet to about Mach 2.

A similar situation exists in relation to the optimum standoff distance between the nozzle exit and the heat receiver. On the basis of existing data, the standoff distance appears critical, with a sharp maximum occurring at a standoff of approximately half a nozzle diameter. For standoffs ranging from 1.5 to 5 diameters, the standoff appears to have little effect on the heat-transfer rate, which may be about 60 per cent of the maximum. These results seem to be influenced by the size of the heat receiver, and possibly by other factors. Experiments in which a rocket exhaust was impinged at an oblique angle on a flat plate have indicated a heat-transfer rate varying cyclically with distance from the point of impingement, as though the jet were alternately detached and reattached to the surface.

No doubt other factors not yet identified may influence heat transfer from rocket-exhaust jets. Chemical effects, probably due to recombination of free radicals, may be important, as heat-transfer coefficients as high as 400 Btu per ft^2/F/hr have been observed in a simple flame, where conventional heat-transfer correlations would predict coefficients in the order of one-tenth this value.

Many possible applications of rocket engines can be envisioned based on (CONTINUED ON PAGE 83)

Training an Astronaut

The seven Project Mercury Astronauts cram at Langley Research Center in preparation for first man-in-space flight

By John Newbauer

LANGLEY RESEARCH CENTER, VA.—"They appear magnified . . . as instruments of a recorded destiny, pushing out into the unknown in obedience to an inward voice, to a dream of the future." Whether the Project Mercury Astronauts can be viewed this romantically, as Joseph Conrad saw the adventurers who explored the South Seas, remains for the seven men chosen for the first U.S. manned spaceflight to witness in their own words. Right now, the Astronauts (see June ASTRONAUTICS, page 22) cram for their unique mission, and appear to take a rather down-to-earth attitude toward the Mercury project. As one candidate put it, "Reliability is one thing we are all pushing for."

The chart at the right outlines Astronaut activities in preparation for Project Mercury build-up flights with the Redstone booster. In addition to these group activities, each Astronaut has an area of specialization which more or less reflects the training he brought to the project.

Each man attends engineering briefings in his specialty and in turn keeps his fellow pilots abreast of the latest information and fine points on the project. (CONTINUED ON PAGE 44)

Astronaut Training Activities

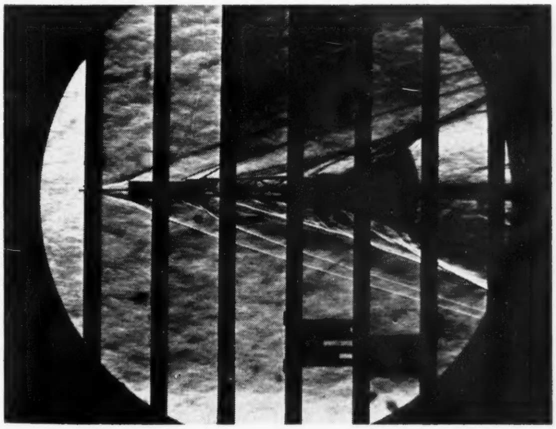
Completed

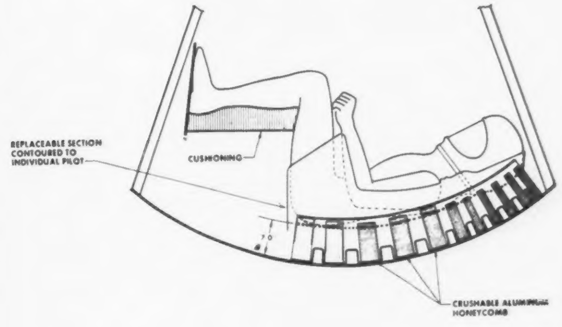
1. McDonnell visit for capsule familiarization
2. Pressure-suit indoctrination at WADC
    a. Centrifuge rides using Redstone and Atlas launch profiles
    b. Re-entry heat profile with suit unpressurized but vented
    c. Pressure-chamber run to 100,000 ft with suit pressurized
    d. Low-residue diets for three days
3. Naval Medical Research Institute, Bethesda, Md.
    a. Determination of basal metabolism, rate of cutaneous blood flow, and sweat rate at 95 and 114 F
    b. Familiarization with effects of excessive CO_2 intake
4. Cape Canaveral visit
    a. Familiarization with BMD and AMR
    b. Study of launching procedures and missiles under development
5. Witnessing of capsule-recovery operation from a destroyer
6. Skin-diving training at Navy's Little Creek Amphibious Base, to simulate effects of weightless state and maintain physical fitness
7. ABMA visit for familiarization with Redstone missile

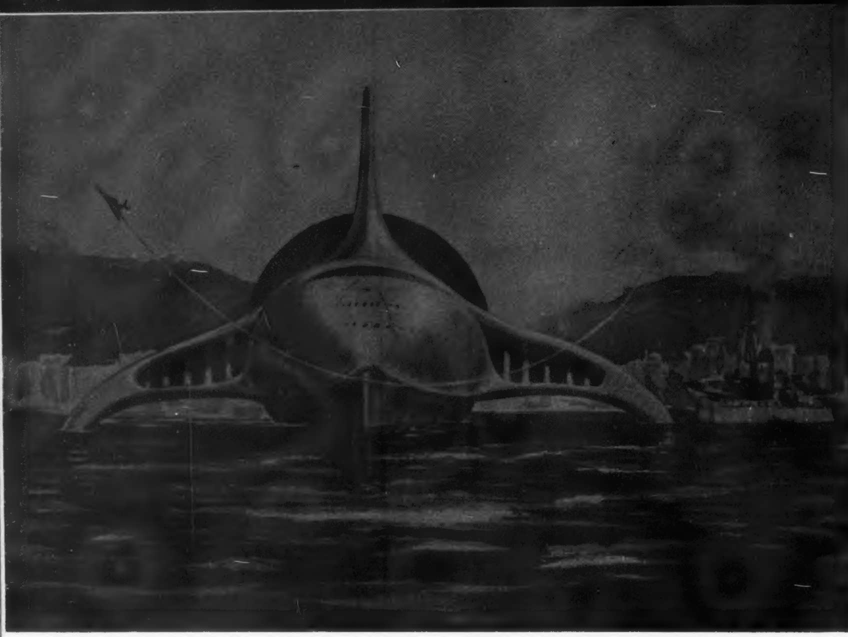
Scheduled

1. Continuation of studies in space mechanics and sciences
2. Continuation of flight and simulator training
3. Acceleration studies with centrifuge at Johnsville
4. Participation in R&D launch and recovery activities
5. Trip to Convair for familiarization with Atlas booster
6. McDonnell visit for checkout procedure and training
7. Fittings for pressure suit at contractor's plant
8. Survival, disorientation, and communication training at Pensacola
9. Edwards AFB visit for X-15 briefing
10. Weightlessness flights for practice in eating and drinking

Schlieren photo, left, shows shock pattern of approximately one-ninth scale model of Mercury capsule undergoing stability study at Mach 3.94 in wind tunnel at Langley Research Center. Right, profile of contour couch and shock-attenuation system.







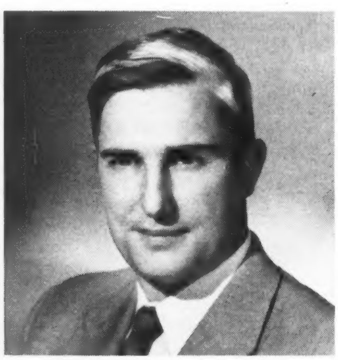
Economical spaceships could rival the largest oceangoing vessels in size, as suggested by this artist's sketch.

Commercially feasible spaceflight

Space vehicles the size of oceangoing vessels, powered by controlled nuclear reactions, will open commercial avenues to the moon and beyond

By Dandridge M. Cole

THE MARTIN COMPANY, DENVER, COLO.



Dandridge M. Cole is a senior advanced planning specialist for Martin-Denver's staff. After receiving an A.B. in chemistry from Princeton Univ. in 1943, he taught and studied until 1953, in the interim also receiving an M.A. in physics from the Univ. of Pennsylvania. Joining Martin-Denver in 1953, he served variously as an armament-analysis, operations, and design engineer on a variety of rocket and missile systems until 1957, when he assumed his present position. He worked on the conceptual design of a nuclear pulse rocket as early as 1956.

CONSIDERATION of the feasibility of commercial spaceflight at this time, when the cost involved in putting a single pound of payload in orbit is something like $100,000, would at first glance appear foolhardy—so foolhardy, in fact, that the past few months have seen publication of a number of statements to the effect that these high costs limit spaceflight to scientific and military projects.

Some men of considerable reputation have even gone on record with the belief that this will always be so, and that there is just no future for commercial astronautical enterprises.

This is simply not the case. While scientific and military projects will undoubtedly dominate the early years of lunar and interplanetary exploration, the possibility of commercial ventures should not be discounted, even at this early date, since there are indications that such ventures may soon become feasible, perhaps as early as the mid-1970's.

An analysis of the effects of improved vehicle performance on the cost per pound of payload for astronautical missions gives results that may be surprising to those who have been unduly concerned over the high costs involved in our first ventures into space.

To begin with, the tremendous sensitivity of payload costs to certain performance and design parameters has not been generally

appreciated. The cost-to-payload ratio of a space rocket is a very sensitive function of rocket gross weight, propellant energy, and the number of powered stages. In particular, the effect of gross weight on over-all economic efficiency has not received sufficient attention.

The ratio of gross weight to payload for the Vanguard rocket is approximately 1000 to 1; that is, the 22,000-lb rocket can put 22 lb in orbit. If the same ratio held for larger rockets, a three-stage vehicle with 10 times the gross weight of the Vanguard, using propellants of the same general performance, could orbit only 220 lb. Actually, this ratio can be improved more than 20 times. For example a rocket similar to a Titan ICBM but with a third powered stage could orbit 2 to 3 tons. This is a ratio of gross weight to payload of 40 or 50 to 1, compared with the Vanguard ratio of 1000 to 1.

Efficiency Increased

Most of this increased efficiency comes from the improvement in vehicle mass ratio with increase in size. A rocket has many fixed-weight components that do not increase in weight as vehicle size increases.

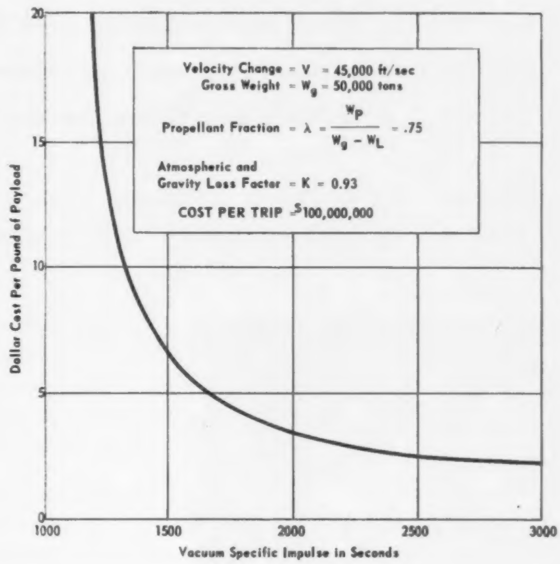
Improved economy will also come from recovery and re-use of rocket vehicles. Initially, recovery of rocket stages may be by parachute, but eventually space vehicles will be designed more like present aircraft, which can be re-used many times.

We can expect, then, that the economical spaceship of the future will be very large, will use very high-energy propellants, and will be capable of re-use in the same manner as present transportation devices.

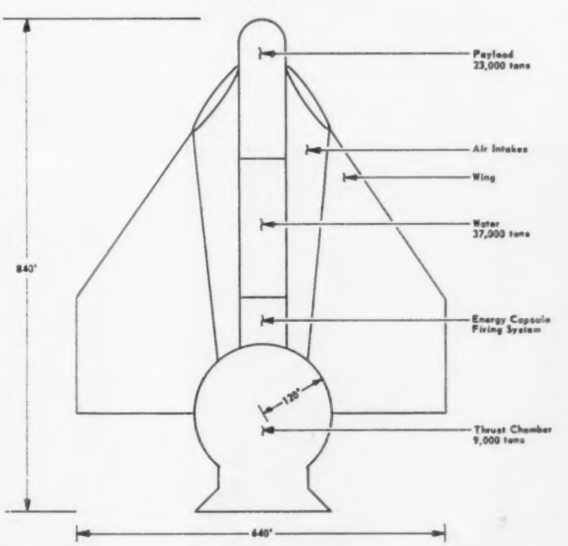
In fact, for many reasons a space vehicle must be comparable in size to present seagoing surface ships to show a profit. Such a size may seem fantastic in comparison with today's aircraft, but we need not restrict ourselves to this comparison. In many ways the spaceship of the future should be more like present seagoing ships than aircraft, and there does not appear to be any technical reason why this similarity should not include size.

It is interesting to note that 15th century vessels were comparable in size and weight to spaceships now on the drawing boards. The ship in which John Cabot discovered North America, for example, weighed 100 tons—the approximate total weight of the first manned satellite vehicle. The flagship of Christopher Columbus, the Santa Maria, was 126 ft long and 26 ft wide—reasonable dimensions for the first manned circumlunar vehicle. The largest ships of the 15th century had gross weights of 1000 to 2000 tons. These are reasonable weights for the first manned circumlunar (CONTINUED ON PAGE 88)

Lunar Vehicle Freight Cost



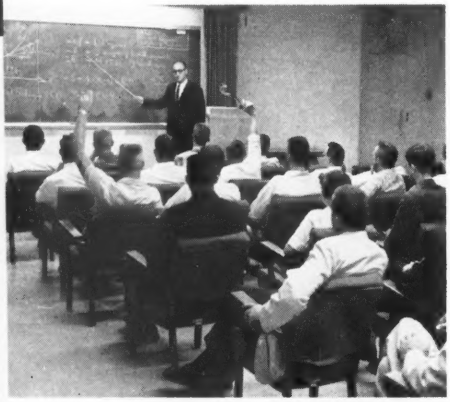
Nuclear Pulse Rocket for Moon Service



ARS Sections meet the challenge

Central Colorado Section sets up broad program aimed at discouraging dangerous experimentation and channeling youngsters' interest into scientific study while offering career guidance in space technology

By Joseph M. Aldrich, MARTIN-DENVER
CHAIRMAN, ARS CENTRAL COLORADO SECTION EDUCATIONAL COMMITTEE ON SPACE TECHNOLOGY



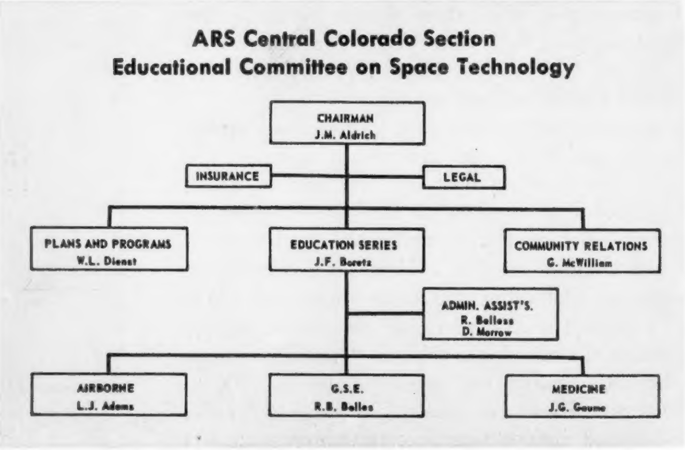
Students and faculty at Colorado Univ. participate in lively lecture by Hubert Reisman on ballistics. Active participation from floor insures interesting evening for audience and lecturer alike.

Harvey Park, Colo., Air Explorer Scouts show intense interest in a discussion of the steps to be taken in reaching outer space.

FINDING an answer to the dangerous increase in hazardous rocket experimentation engendered by the growing interest of American youth in rocketry and astronautics is no easy matter, but a successful step in this direction has been taken by the ARS Central Colorado Section. Under the direction of the Section's Educational Committee on Space Technology, an educational program of great promise, aimed at encouraging the scientific study of rocket principles by actively interested groups and individuals, has been initiated and put into practice. The success of broad public information programs and intensive student orientation activities has already indicated the value of such an approach.

Essential to any effective program is an effective committee, capable of initiating and administering program activities. In forming the committee, every effort was made to insure equitable distribution of the workload over the largest number of members possible. This was felt to be particularly important during the first few months, when the committee was being organized. Also, it was necessary to have adequate subcommittees and sections in order to provide flexibility in administering committee tasks once the program was underway.

Quite often, the first contact other (CONTINUED ON PAGE 62)



# of amateur rocketry

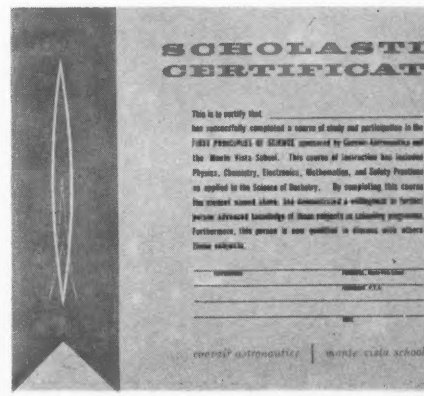
Antelope Valley Section group sets up lecture-demonstration series for grade-school students on science and rocketry to stimulate study of the sciences, warns against dangers of home rocket experiments

By H. E. Coyer, Convair-Astronautics
Member, ARS Antelope Valley Section

IN MID-1957, in cooperation with the school board, the PTAs, and the science teachers of the elementary school district in Lancaster, Calif., a group of ARS Antelope Valley Section members undertook to present a series of lecture-demonstrations on science and rocketry for grade-school students. The main purpose of these classes was to engender in these students a desire for further study of the sciences as their education progressed. The classes were also designed to fill a void in school curricula on subject matter which otherwise could not be covered by the teachers because of time limitations or lack of subject knowledge. And, equally important, the classes were organized to acquaint children with the hazards involved in home rocket experiments.

Since so many of the children in this area have parents working at the Edwards Air Force Base Flight Test Center or Rocket Test Base, natural curiosity concerning jet propulsion and rocketry was at an all-time high. Up until the time these classes started in October 1957, no child or young adult had been injured in home rocket experiments. We are happy to say this record still stands.

The topics chosen for the classes included basic physics, chemistry, electronics, mathematics, astronomy, and atomic energy. The subject matter of each class was slanted toward (CONTINUED ON PAGE 60)



Instructors hold some of the materials presented to the children at the completion of the course in science and rocketry, while the kids proudly clutch certificates (above) awarded to them.

Lancaster, Calif., grade-school students listen attentively to explanation of test-stand facilities at Edwards AFB in the course of field trip to the base.

Sociology and the space age

Astronautics will produce a social revolution, not only affecting the opinions and beliefs of individuals, but also altering the basic social structure and even the form of organization of humanity at large

By Jiri Nehnevajsa

COLUMBIA UNIVERSITY, NEW YORK, N.Y.

Jiri Nehnevajsa is assistant professor of sociology at Columbia Univ. He is also a consultant to Systems Development Corp. and Dunlap & Associates. Born in Czechoslovakia in 1925, he was educated at the universities of Masaryk, Lausanne, and Zurich, and served in the Czech Army in England and the Royal Air Force before coming to this country after WW II. He was an instructor and assistant professor of sociology at the Univ. of Colorado from 1951 to 1956, when he joined the Columbia faculty. Author of numerous articles on sociology, Dr. Nehnevajsa has also authored or co-authored three books. He is a member of the ARS Space Law and Sociology Committee.

THAT gleam in the eye of a number of sociologists these days more often than not is starlight, for the coming of the space age means that new research vistas are opening before him and that he is likely to play an important role in solving some operational problems germane to astronautics and its effects upon humanity.

Some basic assumptions are desirable before any effort can be made to discuss major problem areas of more than tangential relevance to sociologists in the space age. First, we will assume that manned spaceflight is coming, and that man will establish settlements, if not colonies, on other celestial bodies.

Second, we will assume that the timing of such events, while predictable in broad terms, remains uncertain. The effect of this assumption is, among others, that temporal criteria assessing the urgency of salient research programs cannot be readily employed.

Third, we will assume that the effort of sociologists occurs in the context of interrelated scientific endeavors involving similar research on the part of other scientists in such areas as engineering requirements, space medicine, space psychology, etc. Such problems will not be touched upon here, since we are concerned with some particular tasks of the sociologist.

What are some of these tasks? Three types of problems merit attention: First, the effects of the space age on the individuals, and in particular on social processes, opinions, attitudes, and beliefs, and on the goals of individuals; second, the consequences of the space age for the social structure; and, third, the effects of the space age on the forms of organization of humanity at large, in particular from the standpoint of international relations.

Let us consider each of these rather vast problem areas in turn.

Whether, and how, the coming of manned spaceflight will affect the individual's attitudes, opinions, and beliefs is certainly not a question to be answered by an opinion, no matter how authoritative the source. It is a crucial research question of both basic and operational import. Yet, save for somewhat unsystematic surveys or studies designed for very specific purposes, we do not know the distributions of fundamental attitudes, opinions, and beliefs in a global sense. Nor do we know on a worldwide basis what people *want* or *expect*.

The analysis of change in attitudes and opinions becomes meaningful only if it is anchored in the knowledge of existing attitudes and opinions. It is with respect to such attitudes that changes can be assessed, and not otherwise.

The following conclusion can be drawn: We need immediately a *global survey* of the attitudes, opinions, beliefs, and goals of humanity. The task of sociologists (and political scientists) would be to identify the most important opinions we want to know about—questions having to do with one's "philosophy of life," the existence, and characteristics, of a divine power, political orientation, etc.

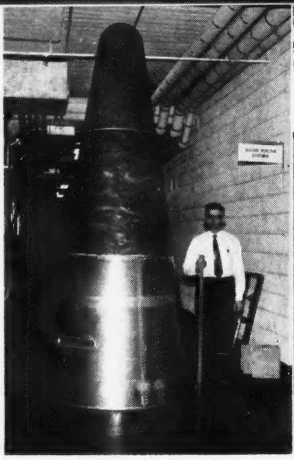
To trace the effects of the space age upon such beliefs and opinions requires regular repetition of such a census. Yet our ability to attribute relevant changes to the space age itself (and thus isolate as much as possible the impact of other important intervening factors—increases and decreases in international tensions, inflationary and recessionary pressures, industrialization and automation) is predicated on the assumption that data on opinions, attitudes, and beliefs be gathered *immediately prior to* the occurrence of manned spaceflight and again *immediately thereafter*, and followed by subsequent studies at regular intervals.

Raising Funds Poses Problems

Since we do not know exactly when manned spaceflight will occur, this poses certain problems. We shall not, at this point, go into the difficulties involved in seeking funds for a research project of this type, other than to note that, in general, funds are made available only for "dated research," that is, research having specific and definable deadlines. At the moment, no organiza- (CONTINUED ON PAGE 72)

The emergence of a possible new elite class of astronauts implies displacement of other elite classes. Which ones? And with what consequences?

At right, the three sections of the liner. Bottom section is aluminum sheet stock, while two top sections are magnesium castings. Scale shown is 4 ft long. Far right, internal view of cast magnesium mid-section, showing internal rings.



Designing an ICBM nose-cone liner

Here's how GE successfully overcame micro-shrinkage and brittleness problems, and produced a satisfactory cast magnesium alloy liner to house the delicate equipment which travels in a missile's nose cone

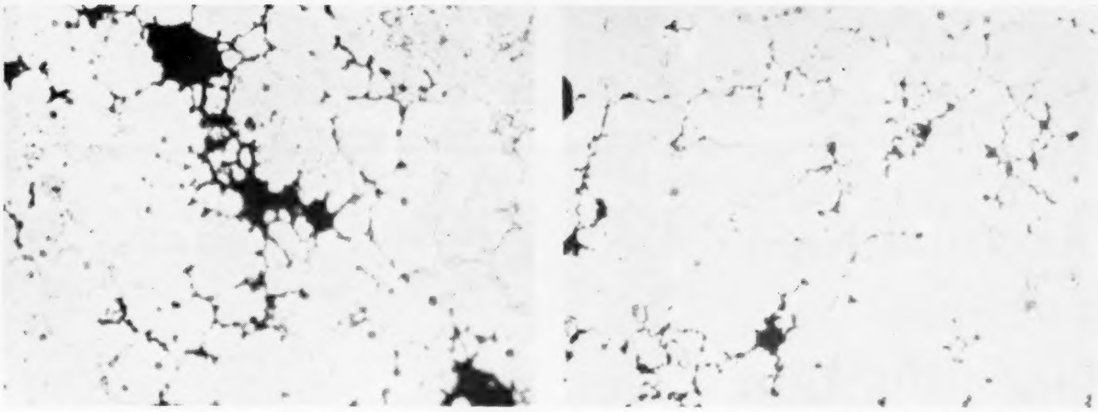
By Bernard H. Gerberg

GE MISSILE AND SPACE VEHICLE DEPT., PHILADELPHIA, PA.

Bernard Gerberg is a design engineer with GE's Missile and Space Vehicle Dept. After three years in the Army, he received a B.M.E. from City College of New York in 1950, with membership in Tau Beta Pi and Pi Tau Sigma. In 1959, he received an M.S. in Mechanical Engineering from Drexel Institute of Technology. Before joining GE in 1956, he did stress analysis and design for Syncro Machine Co. and on jet engines for Curtiss Wright Aircraft Co. At GE, he has worked on nose-cone internal structures, liners, shields, and mechanical methods of propelling and spinning nose cones.

THROUGHOUT its flight, from launch to impact, and particularly at atmospheric re-entry, the re-entry nose cone encounters wide extremes and variations in temperature, pressure, and acceleration. Consequently, to avoid destruction and perform its vital functions, the nose cone must embody system and structural characteristics that, for purposes of discussion, may be likened to those of the human body. For example, the nose cone, like the body, is provided with systems and "organs" to sense its external environment, to record and remember those perceptions, and to communicate or react to the information thus received. And, just as the human body must have a skeleton to house and support its vital organs and a skin to protect them from the elements, so also must the nose cone's delicate equipment be housed in a carefully designed "skeleton," or

Buckled mid-section of liner, showing junction of front and middle sections. Although magnesium alloys are considered brittle, the casting deformed appreciably before cracking.



Effects of micro-shrinkage. Sections taken from thin-wall casting show (left) intergranular voids, in black, in path of crack and (right) relatively sound material away from crack. (**Mag.—100×, acetic-glycol etchant.**)

liner, and be protected by a tough "skin," or shield.

Our purpose here is to examine and discuss in some detail the design of nose-cone liners and the manner in which the protective shield is fabricated to withstand the extremes of hypersonic flight.

The external dimensions and configuration of the nose cone are determined by its flight characteristics. Shield thickness is dictated by expected heat flux and by shield function—that is, whether the shield is to act as a heat sink or as a means of returning heat to its environment by radiation, transpiration (evaporation of liquids), or ablation (sublimation or boiling of the shield material). Aerodynamic and thermodynamic engineering analysis and research determine shield thickness. This, in turn, establishes the inside contour and dimensions of the shield which are the limiting boundaries of the liner. The photo on page 38 shows the liner shape considered here.

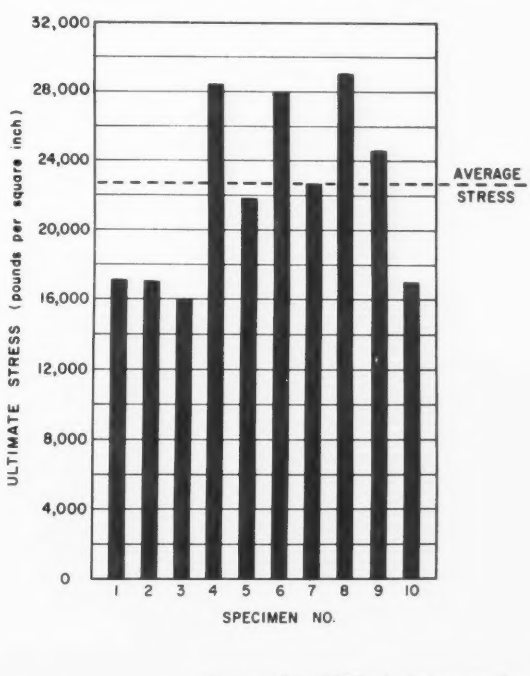
While the shield itself provides protection from heating, the liner must be capable of withstanding the aerodynamic, accelerative, and vibratory stresses imposed during the mission profile. This requirement could be satisfied through the use of a number of materials fabricated by various processes. However, ever-present additional requirements—reliability, minimum weight and cost, and availability and early delivery of materials—severely limit the materials and processes to be used.

To assure adherence to tight delivery schedules, standard grades of aluminum and magnesium were considered and evaluated for resistance to buckling, the critical loading on the nose-cone structure. Weight and Young's Modulus (E) for magnesium are each 65 per cent of the corresponding values for aluminum. Since buckling resistance is proportional to Et^3, where t is thickness, the magnesium structure required to resist a given buckling pressure will weigh 75 per cent less than an aluminum structure of equal strength. In addition, the common heat-treated magnesium alloys provide the same tensile and yield strengths as the standard 356-T6 grade aluminum.

As shown in the photo on page 38, the liner was designed to be made in three sections. The forward and mid-sections are magnesium castings, while the third, or aft, section is built up from aluminum. Cast, rather than built-up, construction was chosen for the first and second sections because of savings potential in casting weight and cost. Weight is reduced by casting the sections to the exact thickness desired. Built-up construction from sheet and angle stock would result in excessive thickness and, hence, greater weight. Price quotations based on a quantity of 30 cast sections averaged 20 per cent less than those for a like quantity of built-up units.

Maintenance of the (CONTINUED ON PAGE 97)

Tension Test Results on Cast Sections



Astronautics decimal classification

Adopted by IAF for a five-year trial period, it provides a useful tool for the filing of references, technical papers, and articles

THE ASTRONAUTICS decimal classification system on these pages is the work of the International Astronautical Federation's Glossary and Documentation Committee, headed by H. H. Koelle of ABMA. Approved by the IAF for a five-year trial period, its purpose is to give the astronautical scientist and engineer a tool for the filing of references, technical papers, articles, and related material in a simple and logical manner.

As Dr. Koelle notes, the system is still under development, and is by no means perfect. While great pains have been taken to avoid overlapping, it could not be completely eliminated, and may never be. However, it does represent the most complete filing system now available, and it is hoped that experience gathered during this five-year trial period will result in a final classification system which can be adopted on a universal basis.

Due to the nature of astronautics, broad coverage of the basic sciences was deemed mandatory. Thus, Groups 0 through 4 are available to file reference material from the general science field which is applicable and of interest to astronautics, while Groups 5 through 9 cover the specific field of astronautics and its applications. A "General Topics" grouping is available for survey reports, definitions, histories, and introductions to the field, and a "Miscellaneous" category for items not covered in the main titles of the group. These may have to be changed and new categories added as time goes on.

It is only through use of the system—the only astronautical classification with international recognition—that its weaknesses can be found. Suggestions for improvements and changes should be sent to Dr. H. H. Koelle, 4522 Panorama Drive, Huntsville, Ala.

Additional copies of the system are available from ARS at a cost of 25 cents each. Write to: Classification, AMERICAN ROCKET SOCIETY, 500 Fifth Ave., New York 36, N.Y.

0 GENERAL FUNDAMENTALS OF THE ASTRONAUTICAL SCIENCES

00 GENERAL TOPICS

000 HUMAN MOTIVES
001 METHODS OF COSMIC EXPLORATION
002 SPACE TRAVEL GENERAL
003 ASTRONAUTICAL RESEARCH
004 PROB. OF ASTRONAUTICAL RESEARCH
005 GEN. SCIENCES IN ASTRONAUT. RESEARCH
006 TEACHING OF ASTRONAUTICAL SCIENCES
007 CLASSIFICATIONS OF ASTRONAUTICS
008
009 MISCELLANEOUS

01 HISTORY

010 GENERAL TOPICS
011 PREHUMAN HISTORY
012 HISTORY OF HUMANITY
013 HISTORY OF SCIENCE
014 HISTORY OF TECHNOLOGY
015 HISTORY OF SURFACE TRANSPORTATION
016 HISTORY OF AERONAUTICS
017 HISTORY OF ASTRONAUTICS
018 PIONEERS OF ASTRONAUTICS
019 MISCELLANEOUS

02 PHILOSOPHY AND PSYCHOLOGY

020 GENERAL TOPICS
021 LOGIC & INDUCTION
022 EPISTEMOLOGY
023 ETHICS & AESTHETICS
024 GENERAL PHILOSOPHY
025 RELIGIOUS PHILOSOPHY
026 CULTURAL & SOCIAL PHILOSOPHY
027 PHILOSOPHY OF HISTORY
028 PSYCHOLOGY
029 MISCELLANEOUS

03 POLITICS & SOCIOLOGY

030 GENERAL TOPICS
031 INDIVIDUALISM
032 UNIVERSALISM
033 SCIENCE OF POLITICS
034 POLITICAL TECHNIQUES
035 COSMOPOLITICS
036 SOCIAL HIERARCHY
037 SOCIOLOGY OF THE SCIENTIST
038 GEOPOLITICS
039 MISCELLANEOUS

04 JURISPRUDENCE & ECONOMICS

040 GENERAL TOPICS
041 INTERNATIONAL LAW
042 NAUTICAL LAW
043 AERONAUTICAL LAW
044 ASTRONAUTICAL LAW
045 NATIONAL ECONOMICS
046 EARTH ECONOMICS
047 SPACE ECONOMICS
048 ASTRONAUTICAL ECONOMIES
049 MISCELLANEOUS

05 LITERATURE & PHILOLOGY

050 GENERAL TOPICS
051 AERONAUTICAL LITERATURE
052 ASTRONAUTICAL LITERATURE
053 PERIODICALS
054 LITERATURE REFERENCES
055 SEMANTICS
056 NATIONAL LANGUAGES
057 WORLD & SPACE LANGUAGES
058 STANDARDIZATION OF TERMINOLOGY
059 MISCELLANEOUS

06 FINE ARTS

060 GENERAL TOPICS
061 CREATIVE ARTS
062 ARCHITECTURE
063 POETRY, PROSE, FICTION
064 MUSIC
065 MOTION PICTURES, TV
066 PAINTING
067 SCULPTURE
068 DANCING
069 MISCELLANEOUS

07 ORGANIZATION

070 GENERAL TOPICS
071 THEORY OF ORGANIZATION
072 ORGANIZATION OF RESEARCH
073 ORGANIZATION OF DEVELOPMENT
074 ORGANIZATION OF MANUFACTURING
075 OPERATIONAL RESEARCH
076
077 CONVENTIONS & EXHIBITIONS, MUSEUMS
078 ROSTER OF EXPERTS
079 MISCELLANEOUS

08 PUBLICITY IN ASTRONAUTICS

080 GENERAL TOPICS
081 SCIENCE OF PUBLICITY
082 MEANS OF PUBLICITY
083 PUBLICITY PLANNING
084 MASS PUBLICITY
085 GOVERNMENT PUBLICITY
086 INDUSTRY PUBLICITY
087 SUCCESS EVALUATION
088 PUBLICITY STATISTICS
089 MISCELLANEOUS

09 EFFECTS AND CONSEQUENCES

090 GENERAL TOPICS
091 ON PHILOSOPHY & GENERAL SCIENCE
092 ON NATURAL SCIENCE
093 ON TECHNOLOGY
094 ON ARTS
095 ON POLITICS
096 ON ECONOMICS
097 ON HUMANITY
098 ON JURISPRUDENCE
099 IN OTHER AREAS

1 SCIENTIFIC FUNDAMENTALS

10 GENERAL TOPICS

100 GENERAL TOPICS
101 NATURAL SCIENCE IN ASTRONAUTICS
102
103
104
105
106
107
108
109 MISCELLANEOUS

11 MATHEMATICS

110 GENERAL TOPICS
111 ARITHMETIC, ALGEBRA
112 TRIGONOMETRY, GEOMETRY
113 INFINITESIMAL CALCULUS
114 VECTOR & TENSOR CALCULUS
115 THEORY OF FUNCTIONS
116 DIFF. & INTEGRAL EQUATIONS
117 CALCULUS OF VARIATIONS
118 MATH. STATISTICS & PROBABILITY THEORY
119 APPLIED MATH. & MISCELLANEOUS

12 ASTRONOMY

120 GENERAL TOPICS
121 DESCRIPTIVE ASTRONOMY
122 OBSERVATION PROCEDURES
123 INSTRUMENTS FOR OBSERVATION
124 SPHERICAL ASTRONOMY
125 CELESTIAL MECHANICS
126 STELLAR STATISTICS
127 COSMOGONY
128 COSMOLOGY
129 MISCELLANEOUS

13 ASTROPHYSICS

130 GENERAL TOPICS
131 METHODS & INSTRUMENTS
132 MOON & PLANETARY PHYSICS
133 SOLAR PHYSICS
134 STELLAR STRUCTURE
135 STELLAR ATMOSPHERES
136 PHYSICS OF NEBULAE
137 INTERPLANETARY & INTERSTELLAR MATTER
138 RADIO ASTRONOMY
139 MISCELLANEOUS

14 GEOPHYSICS & GEODESY

140 GENERAL TOPICS
141 PROPERTIES OF ATMOSPHERIC MODELS
142 IONOSPHERE
143 ATMOSPHERIC HEAT BALANCE
144 METEOROLOGY & CLIMATOLOGY
145 ATM. ACOUSTICS & OPTICS
146 TERRESTRIAL MAGNETISM & ELECTRICITY
147 PHYSICS OF THE INTERIOR OF EARTH
148 GEODESY
149 MISCELLANEOUS

15 GEOLOGY

150 GENERAL TOPICS
151 HISTORICAL GEOLOGY
152 PALEONTOLOGY
153 PHYSICAL GEOLOGY
154 HYDROLOGY
155 SEDIMENTATION
156 MINING ENGINEERING
157 PETROGRAPHY
158 MINERALOGY
159 MISCELLANEOUS

16 GEOGRAPHY

160 GENERAL TOPICS
161 PHYSICAL GEOGRAPHY
162 GEOMORPHOLOGY
163 ECONOMIC GEOGRAPHY
164 POLITICAL GEOGRAPHY
165 CARTOGRAPHY
166 GEOGRAPHY OF SETTLEMENTS
167 GEOGRAPHY OF TRANSPORTATION
168 PLANT GEOGRAPHY
169 MISCELLANEOUS

17 BIOLOGY

170 GENERAL TOPICS
171 MOLECULAR BIOLOGY
172 REGULATORY BIOLOGY
173 STRUCTURAL BIOLOGY
174 GENETIC & DEVELOPMENTAL BIOLOGY
175 ENVIRONMENTAL BIOLOGY
176 SYSTEMIC BIOLOGY
177 SPACE BIOLOGY
178 EXTRA-TERRESTRIAL LIFE
179 MISCELLANEOUS

18 BIOMEDICAL SCIENCES

180 GENERAL TOPICS
181 SEALED CABIN ECOLOGY
182 ACCELERATION, VIBRATION, SONICS
183 FRACTURAL AND ZERO GRAVITY
184 THERMAL EFFECTS
185 RADIATION EFFECTS
186 ESCAPE AND SURVIVAL
187 TOXICOLOGY
188 NUTRITION, WATER & WASTE
189 MISCELLANEOUS

19 BEHAVIORAL SCIENCES

190 GENERAL TOPICS
191 INFORMATION PROCESS & COMMUNICATION
192 HUMAN PERFORMANCE IN SPACE SYSTEMS
193 HUMAN ENGNG. SYSTEMS ANALYSIS
194 VISUAL DISPLAYS & CONTROL CHARACTER
195 WORK SPACE LAYOUT
196 TRAINING EQUIP., TECHNIQUES & SIMULAT.
197 ISOLATION AND CONFINEMENT
198 PERSONNEL SELECTION
199 MISCELLANEOUS

2 PHYSICAL FUNDAMENTALS

20 GENERAL TOPICS

200 GENERAL TOPICS
201 SPACE AND TIME
202 MASS AND ENERGY
203 MATTER AND WAVES
204 STATES OF MATTER
205
206
207
208
209 MISCELLANEOUS

21 THEORETICAL PHYSICS

210 GENERAL TOPICS
211 CLASSICAL MECHANICS
212 KINETIC THEORY OF GASES
213 ACOUSTICS
214 ELECTRICITY
215 MAGNETISM
216 OPTICS
217 STATISTICAL PHYSICS
218 WAVE AND QUANTUM MECHANICS
219

22 THEORETICAL PHYSICS

220 RELATIVISTIC PHYSICS
221 GENERAL FIELD THEORIES
222
223
224
225
226
227
228
229 MISCELLANEOUS

23 SOLID STATE PHYSICS

230 GENERAL TOPICS
231 PROPERTIES OF SOLIDS
232 THEORY OF STATICS
233 THEORY OF ELASTICITY
234 THEORY OF PLASTICITY
235 VIBRATIONS AND OSCILLATIONS
236 CRYSTALLOGRAPHY
237 SEMICONDUCTORS, TRANSISTORS
238 PHENOMENA AT EXTREME LOW TEMP.
239 MISCELLANEOUS

24 THERMODYNAMICS & FLUID DYNAMICS

240 GENERAL TOPICS
241 THERMODYNAMIC PROP. & PARAMETERS
242 FUNDAMENTAL LAWS AND RELATIONSHIPS
243 CHANGES OF STAGE
244 CHEMICAL KINETICS (THERMOD. EQUIL.)
245 IRREVERSIBLE THERMOD.(NON-EQUIL.)
246 HEAT CONDUCTION
247 THERMAL RADIATION
248
249

25 THERMODYNAMICS & FLUID DYNAMICS

250 HYDRODYNAMICS
251 INCOMPR. CONTINUUM FLOW (AEROD.)
252 COMPR. CONTINUUM FLOW (GASD.)
253 SLIP, TRANS, & FREE MOLECULAR FLOW
254 BOUNDARY LAYER & HEAT TRANSFER
255 AERO-THERMOCHEMISTRY
256 COMBUSTION AND FLAMES
257 PLASMA PHYSICS
258 MAGNETO-FLUID DYNAMICS
259 MISCELLANEOUS

26 ELECTRONICS

260 GENERAL TOPICS
261 ELECTRON PROPERTIES
262 PRODUCING AND GUIDING ELECTRONS
263 ELECTRICAL DISCHARGES IN GASES
264 ELECTRON OPTICS
265
266 HIGH FREQUENCY TECHNIQUES
267
268 ELECTRIC & ELECTRONIC EQUIPMENT
269 MISCELLANEOUS

27 PHOTONICS

270 GENERAL TOPICS
271 PROPERTIES OF PHOTONS
272 PRODUCTION OF PHOTONS
273 COLLIMATING OF PHOTONS
274 ABSORPTION OF PHOTONS
275
276
277
278
279 MISCELLANEOUS

28 ATOMIC AND MOLECULAR PHYSICS

280 GENERAL TOPICS
281 ATOMIC & MOLECULAR STRUCTURE
282 MECHANICS OF THE ATOM
283 SPECTRA AND SPECTROSCOPY
284 ATOMIC AND MOLECULAR REACTIONS
285 PERIODIC SYSTEM
286 MAGNETISM OF THE ATOM
287
288 CORPUSCULAR RAYS & EFFECTS
289 MISCELLANEOUS

29 NUCLEAR & PARTICLE PHYSICS

290 GENERAL TOPICS
291 ELEMENTARY PARTICLES
292 NUCLEAR STRUCTURE
293 NUCLEAR REACTIONS
294 NUCLEAR ENERGY
295 NUCLEAR MAGNETISM
296 NUCLEAR SPECTRA
297 COSMIC RADIATION
298 RESEARCH EQUIPMENT
299 MISCELLANEOUS

3 CHEMICAL FUNDAMENTALS

30 GENERAL TOPICS

300 GENERAL TOPICS
301 CHEMISTRY IN ASTRONAUTICS
302 ANALYTICAL CHEMISTRY
303 SYNTHETIC CHEMISTRY
304 APPLIED CHEMISTRY
305
306
307
308
309 MISCELLANEOUS

31 PHYSICAL CHEMISTRY

310 GENERAL TOPICS
311 ELECTRO-CHEMISTRY
312 CAPILLARY CHEMISTRY
313 COLLOIDAL CHEMISTRY
314 MAGNETO-CHEMISTRY
315 PHOTO-CHEMISTRY
316 THERMO-CHEMISTRY
317 CATALYSIS
318
319 MISCELLANEOUS

32 INORGANIC CHEMISTRY

320 GENERAL TOPICS
321 ELEMENTS
322 PERIODIC SYSTEM FROM CHEM. VIEWPOINT
323 LIGHT METALS
324 HEAVY METALS
325 METALLOIDS
326 NON-METALLIC MATERIALS
327 CHEMISTRY OF RADIOACTIVE ELEMENTS
328 ARTIFICIAL ELEMENTS & ISOTOPES
329 MISCELLANEOUS

33 ORGANIC CHEMISTRY

330 GENERAL TOPICS
331 ALIPHATIC COMPOUNDS
332 HYDRO-AROMATIC COMPOUNDS
333 HETEROCYCLIC COMPOUNDS
334 AROMATIC COMPOUNDS
335
336
337
338 SILICON CHEMISTRY
339 MISCELLANEOUS

34 COSMOCHEMISTRY

340 GENERAL TOPICS
341 GEOCHEMISTRY
342 SELENOCHEMISTRY
343 PLANETOCHEMISTRY
344 ASTROCHEMISTRY
345 CHEMISTRY OF INTERSTELLAR MATTER
346
347
348
349 MISCELLANEOUS

35 BIOCHEMISTRY

350 GENERAL TOPICS
351 CALORIMETRY
352 DIGESTION & ABSORPTION
353 WATER - MINERAL METABOLISM
354 CHEMISTRY OF RESPIRATION
355 CHEMISTRY OF TISSUES
356 DETOXICATION
357 CHEMISTRY AND FUNCTION OF ENZYMES
358 CHEMISTRY AND FUNCTION OF HORMONES
359 MISCELLANEOUS

36 CHEMICAL TECHNOLOGY

360 GENERAL TOPICS
361 PRODUCTION OF NUTRITIOUS SUBSTANCES
362 PRODUCTION OF PROPELLANTS
363 PRODUCTION OF MATERIALS
364 PRODUCTION OF AUXILIARY MATERIALS
365
366 CHEMISTRY OF WASTE DISPOSAL
367
368
369 MISCELLANEOUS

37 PROPELLANTS

370 GENERAL TOPICS
371 SOLID PROPELLANTS
372 LIQUID PROPELLANTS
373 HYBRID PROPELLANTS
374 FREE RADICALS
375 WORKING FLUIDS
376 NUCLEAR FUELS
377 OTHER PROPELLANTS
378 HANDLING OF PROPELLANTS
379 MISCELLANEOUS

38 CONSTRUCTION MATERIALS

380 GENERAL TOPICS
381 TESTING OF MATERIALS
382 METALS
383 CERAMICS, STONES, GLASS
384 COMPOUND MATERIALS
385 WOOD, LEATHER, RUBBER
386 FIBROUS MATERIALS
387 PLASTICS
388 PAINTS & LACQUERS
389 MISCELLANEOUS

39 AUXILIARY MATERIALS

390 GENERAL TOPICS
391 LUBRICANTS
392 HYDRAULIC FLUIDS
393 COOLANTS
394 PRESSURIZING GASES
395 SEALING MATERIALS
396 RADIATION SHIELDING MATERIALS
397 EXPLOSIVES
398 IGNITER MATERIALS
399 MISCELLANEOUS

4 TECHNOLOGICAL FUNDAMENTALS

40 GENERAL TOPICS

400 GENERAL TOPICS
401 PURCHASING OF MATERIALS
402 PREPARATION OF MATERIALS
403 LABORATORY SYNTHESIS OF MATERIAL
404 QUALITY OF MATERIALS
405 QUALITY OF MANUFACTURED PARTS
406 CORRELATION OF SUBSTITUTE MAT'LS
407 STORAGE AND HANDLING OF MATERIALS
408 PROBLEMS IN TECHNOLOGY
409 MISCELLANEOUS

41 HEAT TREATING

410 GENERAL TOPICS
411 ANNEALING
412 NORMALIZING
413 STRESS RELIEF
414 HARDENING
415 SOLUTION HEAT TREATING
416 AGING
417 TEMPERING AND TIME-QUENCHING
418 SURFACE HARDENING
419 MISCELLANEOUS

42 SURFACE TREATMENT

420 GENERAL TOPICS
421 METALLIC COATINGS
422 NON-METALLIC COATINGS
423 ENAMELING, LACQUER & PAINT SPRAYING
424 CHEMICAL SURFACE TREATING
425 PLATING
426 CHEMICAL CLEANING
427 BLAST CLEANING
428 SURFACE TREATING BY DIFFUSION
429 MISCELLANEOUS

43 NON-CUTTING SHAPING

430 GENERAL TOPICS
431 CASTING
432 FORGING
433 DRAWING & EXTRUDING
434 ROLLING
435 PRESSING & SWAGING
436 STRETCHING
437 CHEMICAL ETCHING
438 SINTERING
439 MISCELLANEOUS

44 SHAPING BY CUTTING

440 GENERAL TOPICS
441 PLANING
442 SAWING
443 TURNING
444 DRILL, CHAMFER, REAM, BROACH
445 SKIN AND PROFILE MILLING
446 SCRAPING
447 GRINDING, POLISHING, ETC.
448 TREAD-, TAP-, AND GEAR-MILLING
449 MISCELLANEOUS

45 CONNECTING OF MATERIALS

450 GENERAL TOPICS
451 SOLDERING
452 BRAZING
453 WELDING
454 SCREWING AND BOLTING
455 RIVETING
456 ADHESIVE BONDING
457 SHRINKING AND CRIMPING
458 CHEMICAL REACTION
459 MISCELLANEOUS

46 MACHINE ELEMENTS

460 GENERAL TOPICS
461 SHAFTS AND AXLES
462 BEARINGS
463 SEALING ELEMENTS
464 SPRINGS
465 COUPLINGS, CLUTCHES, GEARS
466 VALVES, SLIDE VALVES, FAUCETS
467 CHAINS, ROPES
468 SECURING PARTS
469 MISCELLANEOUS

47 CONSTRUCTION ELEMENTS

470 GENERAL TOPICS
471 AIRFOILS (WINGS)
472 CONTROL SURFACES
473 FUSELAGES
474 LANDING AND FLOATING GEAR
475 RECOVERY EQUIPMENT
476 TANKS AND DUCTS
477 VEHICLE CONTROL ELEMENTS
478 CABIN STRUCTURES
479 MISCELLANEOUS

48 MACHINE TOOLS

480 GENERAL TOPICS
481 MANUFACTURING
482 MANUAL TOOLS
483 ELECTRIC AND PNEUMATIC TOOLS
484 NON-CUTTING MACHINE TOOLS
485 WOODWORKING MACHINES
486 CUTTING MACHINE TOOLS
487 PLASTIC-WORKING MACHINES
488 EQUIPMENT FOR MACHINE TOOLS
489 MISCELLANEOUS

49 ENVIRONMENTAL EFFECTS ON MAT'LS

490 GENERAL TOPICS
491 CORROSION
492 TEMPERATURE EFFECTS
493 VACUUM EFFECTS
494 EFFECTS OF PARTICLES
495 EFFECTS OF ENVIRON, GAS COMPOSITION
496 RADIATION EFFECTS ON MATERIAL
497 EFFECTS OF PRESSURE STRESSES
498 EFFECTS OF TESTING
499 MISCELLANEOUS

5 ASTRIONICS (GUIDANCE & CONTROL)

50 GENERAL TOPICS

500 GENERAL TOPICS
501 THEORY OF MEASUREMENT & ERRORS
502 STANDARDS, GAUGING & CALIBRATION
503 GENERAL INSTRUMENTATION
504 ELECTRICAL MEASURING DEVICES
505 MECHANICAL MEASURING DEVICES
506 OPTICAL MEASURING DEVICES
507 OTHER MEASURING DEVICES
508 FREE FLIGHT MEASUREMENT TECHNIQUES
509 MISCELLANEOUS

51 CONTROL TECHNIQUES

510 GENERAL TOPICS
511 THEORY OF CONTROL
512 MEANS OF ATTITUDE CONTROL
513 MEANS OF FLOW RATE CONTROL
514 MEANS OF THRUST CONTROL
515 MEANS OF PRESSURE CONTROL
516 MEANS OF TEMPERATURE CONTROL
517
518 COMBINED CONTROL SYSTEMS
519 MISCELLANEOUS

52 GUIDANCE SCHEMES AND SYSTEMS

520 GENERAL TOPICS
521 RADIO INERTIAL GUIDANCE
522 FULL INERTIAL GUIDANCE
523 HOMING GUIDANCE (INFRARED & RADAR)
524 OPTICAL AND TV GUIDANCE
525 MAGNETIC GUIDANCE
526
527
528 COMBINED GUIDANCE SYSTEMS
529 MISCELLANEOUS

53 GUIDANCE AND CONTROL COMPONENTS

530 GENERAL TOPICS
531 GYROS (GENERAL)
532 STABILIZERS
533 ACCELEROMETERS
534 SPECIAL GUIDANCE COMPUTERS
535 HORIZON SEEKERS
536 STAR TRACKERS
537 RATE GYROS
538
539

54 GUIDANCE AND CONTROL COMPONENTS

540 ANGLE-OF-ATTACK METERS
541 FLYWHEEL SYSTEMS
542 TIMER AND PROGRAM DEVICES
543 TRACKING COMPONENTS
544 ANTENNAS
545 SAFETY AND DESTRUCTION DEVICES
546
547
548 ACTUATORS, SERVOMECHANISM
549 MISCELLANEOUS

55 NETWORK AND POWER SOURCES

550 GENERAL TOPICS
551 ELECTRICAL WIRING AND DISTRIBUTORS
552 BATTERIES AND FUEL CELLS
553 PRIME MOVERS, GENERATORS & INVERTERS
554 AUXILIARY POWER PACKAGES
555 SOLAR POWER GENERATORS
556 NUCLEAR POWER GENERATORS
557
558
559 MISCELLANEOUS

56 TELECOMMUNICATION EQUIPMENT

560 GENERAL TOPICS
561 ELECTRONIC COMPONENTS
562 TELEGRAPHY
563 TELEPHONY, RADIO
564 TELEMETERING DEVICES
565 ACOUSTICAL EQUIPMENT
566 OPTICAL EQUIPMENT
567
568 INTERFERENCE
569 MISCELLANEOUS

57 COMPUTERS AND AUTOMATION

570 GENERAL TOPICS
571 ANALOG COMPUTERS
572 MECHANICAL DIGITAL COMPUTERS
573 ELECTRONIC DIGITAL COMPUTERS
574 FLIGHT SIMULATORS
575
576 DATA PROCESSING & PRESENTATION
577 COMPUTER RELIABILITY
578 SPECIAL FIELDS OF APPLICATION
579 MISCELLANEOUS

58 PHOTOGRAPHY

580 GENERAL TOPICS
581 PHOTOGRAPHY WITH VISIBLE LIGHT
582 INFRARED & ULTRAVIOLET PHOTOGRAPHY
583 SCHLIEREN & STROBOSCOPIC PHOTOGRAPHY
584 PHOTOCHEMICAL PROCESSES
585 STILL CAMERAS
586 MOTION PICTURE CAMERAS
587 PHOTOGRAMMETRY
588
589 MISCELLANEOUS

59 TELEVISION

590 GENERAL TOPICS
591 BASIC COMPONENTS
592 BLACK & WHITE TELEVISION
593 COLOR TELEVISION
594 CAMERA TUBES
595 STORAGE DEVICES
596
597
598 SPECIAL APPLICATIONS
599 MISCELLANEOUS

6 FLIGHT MECHANICS AND NAVIGATION (ASTRODYNAMICS)

60 GENERAL TOPICS

600 GENERAL TOPICS
601 INTEGRATION METHODS IN BALLISTICS
602 COORDINATE SYSTEMS
603 TRAJECTORY MEASUREMENTS METHODS
604 ENVIRONMENTAL FACTORS
605
606
607 CATALOGUES OF TRAJECTORIES & ORBITS
608 MAPS OF TRAJECTORIES & ORBITS
609 MISCELLANEOUS

61 LAUNCHING DYNAMICS

610 GENERAL TOPICS
611 UNASSISTED TAKEOFF
612 ASST. TAKEOFF WITH ONBOARD DEVICES
613 ASST. T/O WITH JETTISONABLE DEVICES
614 ASST. TAKEOFF FROM AIRCRAFT
615 TAKEOFF FROM SHIPBOARD LAUNCHER
616
617
618
619 MISCELLANEOUS

62 STABILITY AND CONTROL

620 GENERAL TOPICS
621 STATIC STABILITY
622 DYNAMIC STABILITY
623 SOURCES OF PERTURBATIONS
624 CONTROL SCHEMES SYSTEMS
625 TIDAL AND GYRO FORCES
626 AERO-ELASTIC EFFECTS ON CONTROL
627 SLOSHING
628 ACCURACY INVESTIGATIONS
629 MISCELLANEOUS

63 POWERED TRAJECTORIES

630 GENERAL TOPICS
631 POWERED ASCENT WITHOUT ATMOSPHERE
632 POWERED ASCENT WITH ATMOSPHERE
633 POWERED DESCENT
634 LOW POWERED MOTION
635 POWERED ESCAPE AND CAPTURE
636 INTERSTELLAR POWERED TRAJECTORIES
637 POWERED MANEUVERS
638 PERTURBATIONS
639 MISCELLANEOUS

64 FREE FLIGHT TRAJECTORIES

640 GENERAL TOPICS
641 PATH IN CENTRAL FORCE FIELD
642 PATH IN QUASI-CENTRAL FORCE FIELD
643 ESCAPE AND CAPTURE
644 INTERPLANETARY PATH
645 INTERSTELLAR PATH
646 PATH WITH EXTREME ATMOSPHERIC DRAG
647 OTHER PERTURBATIONS
648
649 MISCELLANEOUS

65 SATELLITE MECHANICS

650 GENERAL TOPICS
651 EQUATORIAL & INCLINED ELLIPT. ORBITS
652 ORBITAL PATH PROJECTION
653 VIEWING AREAS FROM SATELLITES
654 ILLUMINATION AND VISIBILITY
655 SKIN TEMPERATURE
656 PERTURBATIONS
657 LIFETIME
658 TRAJECTORY STABILITY & CORRECTION
659 MISCELLANEOUS

66 ATMOSPHERIC ENTRY

660 GENERAL TOPICS
661 DESCENT WITHOUT LIFT
662 DESCENT WITH VARIABLE AIR BRAKES
663 DESCENT WITH LIFT
664 ELECTROMAGNETIC DRAG FORCES
665 FLIGHT PATH OSCILLATIONS
666 MANEUVERING DURING RE-ENTRY
667 HARD AND SEMI-HARD IMPACT
668 LANDING
669 MISCELLANEOUS

67 FLIGHT PERFORMANCE

670 GENERAL TOPICS
671 TRANSPORTATION REQ. FOR MISSIONS
672 ENERGY AND VEL. REQ. FOR MISSIONS
673 CUTOFF VELOCITY REQUIREMENTS
674 VEHICLE VELOCITY CAPABILITIES
675 ANALYTICAL PERFORMANCE CAL.
676 PREDICTED TRAJECTORIES
677 ACTUALLY FLOWN TRAJECTORIES
678 TOTAL MISSION EFFORT PARAMETERS
679 MISCELLANEOUS

68 PRINCIPLES OF NAVIGATION

680 GENERAL TOPICS
681 NAVIGATION PREPARATIONS FOR MISSION
682 ASTRONOMICAL NAVIGATION IN SPACE
683 FULL INERTIAL NAVIGATION
684 RADIO AND RADAR NAVIGATION
685 COURSE CORRECTIONS
686 TERRESTRIAL NAVIGATION AT RE-ENTRY
687 BLIND FLYING DURING LANDING
688 TELECOMMUNICATION METHODS
689 MISCELLANEOUS

69 NAVIGATIONAL INSTRUMENTS AND AIDS

690 GENERAL TOPICS
691 MAPS, CHARTS, PLANETARIA
692 SCHEDULES AND TIME TABLES
693 GYRO INSTRUMENTS FOR NAVIGATION
694 OPTICAL INSTRUMENTS FOR NAVIGATION
695 RADIO AND RADAR EQUIP. FOR NAVIG.
696 AUTOMATIC NAVIGATION DEVICES
697
698
699 MISCELLANEOUS

7 PROPULSION SYSTEMS

70 GENERAL TOPICS

700 GENERAL TOPICS
701 METHODS OF PROPULSION
702 PROPULSIVE JETS
703 CLASSIFICATION OF PROPULSION SYSTEMS
704 CONSTRUCTION PROBLEMS PROP. SYS.
705 TEST PROCEDURES & PROBLEMS PROP. SYS.
706 INSTALLATION OF PROPULSION SYSTEMS
707
708 COLLATION OF PROPULSION SYSTEM DATA
709 MISCELLANEOUS

71 THEORY OF PROPULSION SYSTEMS

710 GENERAL TOPICS
711 THRUST AND EFFICIENCY
712 PROPELLANT SUPPLY
713 PROPELLANT INJECTION AND MIXING
714 COMBUSTION PARAMETERS & STABILITY
715 INTERIOR FLOW
716 HEAT TRANSFER AND COOLING
717
718
719 MISCELLANEOUS

72 PROPULSION SYSTEM ELEMENTS

720 GENERAL TOPICS
721 DIFFUSERS
722 FLOW ENGINES
723 INJECTORS
724 COMBUSTION (HEATING) CHAMBERS
725 NOZZLES
726 GAS GENERATORS
727 HEAT EXCHANGERS
728 PRESSURIZATION SYSTEMS
729 MISCELLANEOUS

73 AIR-JET PROPULSION SYSTEMS

730 GENERAL TOPICS
731 PROPELLER RECIPROCATING ENGINES
732 TURBOPROP ENGINES
733 PULSE-JET ENGINES
734 TURBOJET ENGINES
735 TURBO-RAMJET ENGINES
736 RAMJET ENGINES
737 OTHER COMBINED PROPULSION SYSTEMS
738 SPECIAL AIR-JET PROPULSION SYSTEMS
739 MISCELLANEOUS

74 CHEMICAL ROCKET PROPULSION SYSTEMS

740 GENERAL TOPICS
741 DOUBLE BASE SOLID PRO. PROP. SYS.
742 COMPOSITE SOLID PRO. PROP. SYS.
743 LIQUID MONOPROPELLANT PROP. SYS.
744
745 PRESSURE-FED LIQ. BIPRO. PROP. SYS
746 PUMP-FED LIQ. BIPRO. PROP. SYS.
747 FREE RADICAL PRO. PROP. SYS.
748 COMBINED PROPULSION SYSTEMS
749 MISCELLANEOUS

75 NUCLEAR ENERGY PROPULSION SYSTEMS

750 GENERAL TOPICS
751
752 FISSION PROPULSION SYSTEMS
753 FUSION PROPULSION SYSTEMS
754
755
756 REACTOR TECHNIQUES
757 NUCLEAR MODERATOR
758 RADIATION SHIELDING REQUIREMENTS
759 MISCELLANEOUS

76 ELECTRIC REACTION PROPULSION SYSTEMS

760 GENERAL TOPICS
761 ELECTROSTATIC PROPULSION SYSTEMS
762 ELECTROMAGNETIC PROPULSION SYSTEMS
763 PROTON PROPULSION SYSTEM
764
765
766
767 IONIZATION METHODS
768
769 MISCELLANEOUS

77 PHOTONIC REACTION PROPULSION SYSTEMS

770 GENERAL TOPICS
771 REFLECTORS
772 NUCLEAR PHOTON SOURCES
773
774
775
776
777 PARTIAL PHOTONIC PROPULSION SYSTEMS
778 TOTAL PHOTONIC PROPULSION SYSTEMS
779 MISCELLANEOUS

78 SPECIAL PROPULSION SYSTEMS

780 GENERAL TOPICS
781 HOT WATER ROCKETS
782 SOLAR RADIATION PROPULSION
783
784
785
786
787
788
789 MISCELLANEOUS

79 POWER PLANT ACCESSORIES

790 GENERAL TOPICS
791 PIPINGS
792 CONTROL CIRCUITS
793 STARTERS
794 IGNITION SYSTEMS
795 CONTROL INSTRUMENTATION & INDICATORS
796 CONTROL SYSTEMS & DEVICES
797 HYDRAULIC EQUIPMENT
798 ENGINE THRUST FRAMES
799 MISCELLANEOUS

8 AIR AND SPACE VEHICLES

80 GENERAL TOPICS

800 GENERAL TOPICS
801 THEORY OF AIR & SPACE VEHICLES
802 DESIGN OF AIR & SPACE VEHICLES
803 TESTING OF AIR & SPACE VEHICLES
804 ASSEMBLY & CHECKOUT PROCEDURES
805 OPERATIONAL REQUIREMENTS
806 RELIABILITY CONCEPTS
807 PAYLOAD DATA
808 COLLATION OF VEHICLE DATA
809 MISCELLANEOUS

81 PPINCIPLES OF DESIGN

810 GENERAL TOPICS
811 DESIGN CRITERIA
812 MULTISTAGE THEORY
813 STRUCTURAL LAYOUT
814 POWER PLANT SELECTION
815 GUIDANCE AND CONTROL SYS. SELECTION
816 PERFORMANCE RESERVE REQUIREMENTS
817 SAFETY REQUIREMENTS
818 PAYLOAD REQUIREMENTS
819 MISCELLANEOUS

82 STATICS AND STRESS ANALYSIS

820 GENERAL TOPICS
821 ASSUMPTIONS OF LOADS
822 CALCULATION METHODS
823 STRESS CALCULATIONS
824 STRUCTURAL TESTS
825 AERO-ELASTICITY
826 FATIGUE, VIBRATIONAL STRAIN
827 FLUTTER
828 WEIGHT DETERMINATION (& MOMENTS)
829 MISCELLANEOUS

83 AIRCRAFT

830 GENERAL TOPICS
831 BALLOONS & RIGID AIRSHIPS
832 SOARING PLANES & GLIDERS
833 FLAPPING WING AIRCRAFT
834 HELICOPTERS & AUTOGIROS
835 PROPELLER AIRCRAFT
836 AIRBREATHING JET AIRCRAFT
837 ROCKET POWERED AIRCRAFT
838 SMALL BALLISTIC PROJECTILES
839 MISCELLANEOUS

84 MISSILES AND CARRIER VEHICLES

840 GENERAL TOPICS
841 AIR-TO-AIR MISSILES
842 AIR-TO-SURFACE MISSILES
843 SURFACE-TO-AIR MISSILES
844 SOUNDING ROCKETS
845 SMALL SURFACE-TO-SURFACE MISSILES
846 BALLISTIC MSL & TRANSPORT VEHICLES
847 ORBITAL CARRIER VEHICLES
848 GROUND LAUNCHED SPACE PROBE CARR.
849 MISCELLANEOUS

85 SATELLITE VEHICLES

850 GENERAL TOPICS
851 PRINCIPLES OF DESIGN
852 CONSTRUCTION ELEMENTS
853 SUBASSEMBLIES OF SATELLITES
854 EARTH SATELLITES
855 LUNAR SATELLITES
856 PLANETARY SATELLITES
857 SOLAR SATELLITES
858 SCIENTIFIC INSTR. IN SATELLITES
859 MISCELLANEOUS

86 SPACE VEHICLES

860 GENERAL TOPICS
861 EARTH-MOON VEHICLES
862 INTERPLANETARY VEHICLES
863 INTERSTELLAR VEHICLES
864 INTERGALACTIC VEHICLES
865 SPACE FERRIES FOR INTERORBITAL TRAN.
866 SPACE TAXIES FOR ORBITAL TRANSFER
867 TOOL CARRIERS AND WORKING SUITS
868 SPECIAL LANDING VEHICLES
869 MISCELLANEOUS

87 ACCESSORIES (NON-REMOVABLE)

870 GENERAL TOPICS
871 AIR CONDITIONING SYSTEMS
872 NUTRITION SYSTEMS
873 INTERIOR EQUIPMENT
874
875
876
877
878
879 MISCELLANEOUS

88 EQUIPMENT (REMOVABLE)

880 GENERAL TOPICS
881 SAFETY EQUIPMENT
882 RESCUE EQUIPMENT (SPACE SUITS)
883 PORTABLE AIR CONDITIONERS
884 PORTABLE NUTRITION SYSTEMS
885 MOVABLE INTERIOR EQUIPMENT
886 TOOLS AND SPARES
887 MEDICAL EMERGENCY KITS
888
889 MISCELLANEOUS

89 PILOTING

890 GENERAL TOPICS
891 OPERATION MANUALS
892 OPERATIONAL CONTROL OF PROP. SYS.
893 OPERATIONAL CONTROL OF VEHICLE
894 OPERATIONAL CONTROL OF FLIGHT PATH
895 RESCUE OPERATIONS
896 CREW PREFLIGHT CHECKOUT PROCEDURE
897 CREW ROUTINE FLIGHT PROCEDURES
898 CREW TRAINING
899 MISCELLANEOUS

9 GROUND INSTALLATIONS-EQUIPMENT

90 GENERAL TOPICS AND GROUND ORGANIZ.

900 GENERAL TOPICS
901 ASTRONAUTICAL SYSTEM ORGANIZATION
902 ASTRONAUTICAL GROUND INSTALLATIONS
903 POLITICAL ORGANIZATIONS
904 ECONOMICAL ORGANIZATIONS
905 SCIENTIFIC ORGANIZATIONS
906 TECHNICAL ORGANIZATIONS
907 MILITARY ORGANIZATIONS
908 NAT. & INTERNAT. ASTRON. ASSOCIATIONS
909 MISCELLANEOUS

91 RESEARCH FACILITIES

910 GENERAL TOPICS
911 RESEARCH INSTITUTES
912 LABORATORIES
913 WIND TUNNEL & SHOCK TUBES
914 BALLISTIC TEST RANGES
915 NUCLEAR RESEARCH FACILITIES
916 ROCKET SLEDS
917 VACUUM CHAMBERS
918 RESEARCH & DEVELOPMENT ORGANIZATIONS
919 MISCELLANEOUS

92 DEVELOPMENT FACILITIES

920 GENERAL TOPICS
921 DEVELOPMENT ORGANIZATIONS
922 TEST STATIONS
923 FLIGHT TEST RANGES
924 STATIC TEST FACILITIES
925
926
927
928 DEVELOPMENT & MANUFACTURING ORGAN.
929 MISCELLANEOUS

93 PRODUCTION FACILITIES

930 GENERAL TOPICS
931 PRODUCTION AND ASSEMBLY PLANTS
932 POWER PLANT INDUSTRY
933 ELECTRONIC INDUSTRY
934 ACCESSORY INDUSTRY
935 MAINTENANCE & REPAIR INSTALL.
936 SUPPLY BASES
937
938 ROSTER OF MANUFACTURERS
939 MISCELLANEOUS

94 LAUNCHING SITES AND SPACE PORTS

940 GENERAL TOPICS
941 CONSTRUCTION
942 OPERATION
943 MAINTENANCE
944 HANGARS
945 LAUNCHING FACILITIES
946 LANDING FACILITIES
947 TRAFFIC CONTROL FACILITIES
948 STORAGE AREAS
949 MISCELLANEOUS

95 TRACKING AND COMMUNICATION INSTALL.

950 GENERAL TOPICS
951 VISUAL OBSERVATION FACILITIES
952 TRACKING FACILITIES
953 TELECOMMUNICATION FACILITIES
954 MEASURING AND TELEMETRY FACILITIES
955
956
957
958
959 MISCELLANEOUS

96 PROPELLANT SUPPLY & STORAGE

960 GENERAL TOPICS
961 SOLID PROPELLANTS
962 LIQUID MONOPROPELLANTS
963 LIQUID FUELS
964 LIQUID OXIDIZERS
965 NUCLEAR FUELS
966 NUCLEAR WORKING FLUIDS
967 PRESSURIZATION
968 SAFETY REQUIREMENTS
969 MISCELLANEOUS

97 LAUNCHING PREPARATION

970 GENERAL TOPICS
971 HANDLING OF LARGE MISSILES
972 SAFETY CONSIDERATIONS
973 COUNTDOWN PROCEDURES
974 FUELING PROCEDURES
975
976
977
978
979 MISCELLANEOUS

98 LOGISTICS AND TRANSPORTATION

980 GENERAL TOPICS
981 TRANSPORTATION (GENERAL)
982 SERVICE STRUCTURES
983 CRANES AND LIFTING DEVICES
984 GROUND TRANSPORT VEHICLES
985 SHIPS
986 SELF-SUSTAINING GROUND TSPT. VEH.
987 RECOVERY OPERATIONS
988 PRESERVATION OF VEHICLES
989 MISCELLANEOUS

99 EXTRA-TERRESTRIAL BASES

990 GENERAL TOPICS
991 MOON SETTLEMENTS
992 PLANETARY LUNAR SETTLEMENTS
993 PLANETARY SETTLEMENTS
994
995
996
997
998 EXTRA-TERRESTRIAL SUPPORT EQUIPMENT
999 MISCELLANEOUS

Training an Astronaut

(CONTINUED FROM PAGE 31)

The Astronauts, with their areas of specialization, are:

Malcolm S. Carpenter	—Navigation and Navigational Aids
Leroy G. Cooper	—Redstone Booster
John H. Glenn	—Crew Space Layout
Virgil I. Grissom	—Automatic and Manual Attitude Control Systems
Walter M. Schirra	—Life Support System
Alan B. Shepard	—Range, Tracking, and Recovery Operations
Donald K. Slayton	—Atlas Booster

This thoughtful training program should make it possible for the Astronauts to approach the coming Project Mercury build-up flights with self-confidence and esprit de corps.

Engineering of the Mercury capsule itself has gone (see June ASTRONAUTICS, page 30) through a number of minor shifts. Landing shock will be absorbed by a 7-in. thick layer of crushable aluminum honeycomb between the contour couch and the heat shielding, instead of by an inflated external pillow as proposed at first. The contour couch will terminate at the pilot's thighs, and his calves and feet will be supported by separate cushioning, as indicated in the sketch on page 31. The sides of the contour seat extend well up against the sides of the pilot's body, thus giving him support under lateral acceleration.

Lateral acceleration and shock appear to constitute one small question in the Project Mercury plans. Prolonged lateral acceleration could possibly derange the pilot, but it does not seem likely that this motion will arise in the Mercury flight. As of the moment, no capsule flights are planned with a "proximate-human" dummy, rather than the actual pilot, to test flight accelerations and structural adequacy.

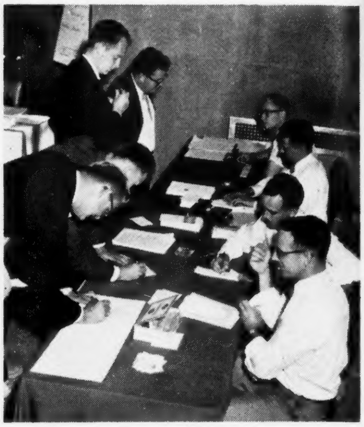
Drag Probe Added

Externally, the drag probe proposed by S. M. Bogdonoff and I. E. Vas of Princeton's Forrestal Research Center has been added atop the retrorocket escape system, as shown in the photograph on page 31. The capsule skin of thin, high-cobalt alloy sheeting, which withstands temperatures up to 1700 F with good strength, will be corrugated to add as much wall strength as possible. The heat shield could be either beryllium or an ablating resin with filler.

Many more adjustments will doubtless be made, as in any development, before *the* capsule sits at Cape Canaveral.

The Astronauts—from left, Navy Lt. Malcolm Carpenter, AF Capt. Donald Slayton, AF Capt. Leroy Cooper, Navy Lt. Cmdr. Alan Shepard, Marine Lt. Col. John Glenn, AF Capt. Virgil Grissom, and Navy Lt. Cmdr. Walter Schirra—examine model of Mercury capsule and Little Joe rocket, which will be used in developmental flight tests of the capsule system. ◆◆

The meeting place—Ohio Union on the Ohio State Univ. campus.



Members of the Columbus Section manning the registration desk sign up early birds.

Propellant Thermodynamics and Handling Conference Points Ahead

Ohio Union's modern meeting rooms made listening easy.

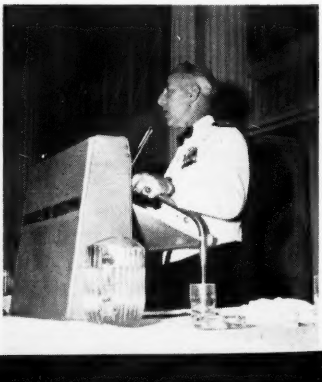
A good meeting draws a representative attendance of the technical community, acts as an incentive to present unclassified research and development that otherwise might lounge in the classified literature, offers a chance to debate new work, and provides the organization and convivial surroundings to do these things gracefully.

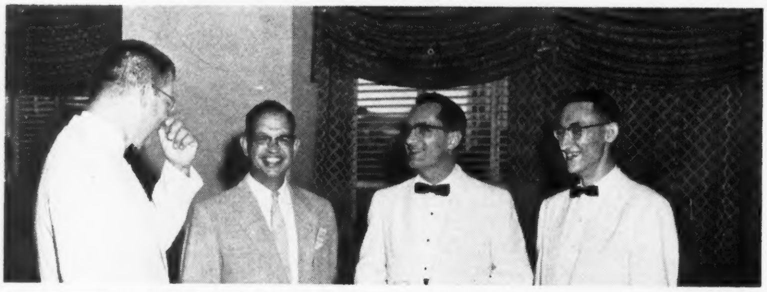
By these or any other standards, the ARS Propellant Thermodynamics and Handling Conference was an excellent meeting.

Held July 20 and 21 in the spacious Ohio Union building on the campus of Ohio State Univ., under the sponsorship of the ARS Propellants and Combustion Committee in cooperation with Battelle Memorial Institute and the Dept. of Aeronautical Engineering of Ohio State Univ., the meeting drew a fine attendance of something over 400. The meeting went smoothly under the able direction of co-chairmen Loren Bollinger of Ohio State's Rocket Research Lab and Alexis Lemmon of Battelle. ARS Columbus Section members gave plentifully of their time and effort to make arrangements for the meeting, and the arrangements were carried out in a workmanlike manner.

The speakers for the banquet, held in the Dressler-Hilton Hotel in downtown Columbus the evening of July 20, and the two luncheons were appropriate, and gave timely talks. Banquet speaker Rear Admiral John E. Clark, USN, Deputy Director of

Left, head table at the banquet. From left, meeting co-chairman Loren Bollinger; George Gehrkens, chief engineer of North American-Columbus; Gordon B. Carson, vice-president of Ohio State; ARS President John P. Stapp; Capt. Charles E. McCombs, USN, of Ohio State; Rear Adm. John E. Clark, USN, at the rostrum; Columbus Section President Emerson W. Smith; Edward E. Slowter, vice-president of Battelle; Herrick L. Johnston of Herrick L. Johnston Inc.; Garvin L. VonEschen, chairman of Ohio State's AE Dept.; and co-chairman Alexis W. Lemmon Jr. At right, Adm. Clark, Deputy Director of ARPA, gives banquet address on "The U.S. Technological Posture."





At the reception given by Herrick L. Johnston Inc.: Top, chiefs looking pleased —from left, Alex Lemmon, Loren Bollinger, Col. Stapp, Rear Adm. Clark, George Gehrkens, and Emerson Smith; next, Indians looking pleased (They shall be nameless); next, meeting planners looking jovial—John Sloop, ARS Propellants and Combustion Committee Chairman, in grey suit; and bottom, ladies brightening assemblage—left, Mrs. Emerson W. Smith and, right, Mrs. John P. Stapp.

ARPA, addressed a capacity audience on "The U.S. Technological Posture." The drift of his comments was that ARPA is promoting greater exercise of the nation's research muscles, in an effort to improve that posture. At the July 20 luncheon, Gordon B. Carson, vice-president for business and finance of Ohio State Univ., spoke on "Science, Technology, and Wisdom." It was interesting to hear him equate science with Cardinal John H. Newman's idea of a university, and to put the problem of national survival in the modern technological world squarely at the doorsteps of educational institutions. At the Tuesday luncheon, Edward E. Slowter, vice-president of Battelle Memorial Institute, gave an analysis of planning complex research and development in terms of its anticipated profit.

The meeting itself was conducted without preprints of the papers presented. This may account for a kind of understatement to its proceedings, giving delayed impact to the many noteworthy accomplishments and activities in thermodynamics and handling revealed in the excellently organized sessions. Among other things, the meeting served to lay to rest some 10 years of research on the thermodynamics of the B-O-H system up to temperatures of about 2000 K; to announce that the practical problems attending the handling and use of liquid hydrogen and liquid fluorine in rocket-engines test equipment have been solved in good measure; and to reveal that much performance analysis for rocket engines still depends on iteration methods for equilibrium conditions.

There was brought to light through a discussion by E. J. Largent, of Reynolds Metals Co., on the toxicity of fluorine and hydrogen fluoride the potential danger of low concentrations of hydrogen fluoride to workmen and

Conference Proceedings Available Nov. 1

Proceedings of the Propellant Thermodynamics and Handling Conference, to be published by Ohio State Univ. Press, will be available Nov. 1 from the OSU Publications Office, Engineering Experiment Station, 156 W. 19th Ave., Columbus 10, Ohio, at a cost of $2.50 each. *Send money order or check made out to Ohio State Univ. with your order.*

The End.

plant life. And there was the casual announcement at the end of the paper by Harold W. Schmidt of NASA Lewis Research Center on "Some Problems in Using Fluorine in Rocket Systems" that a liquid fluorine rocket engine should now be practical, providing there is an important enough mission for one.

Most significant in the long run, the meeting pointed to the important work in progress on the thermodynamics of light elements. The methodology of study at high temperatures appears to be gaining force, and with the support of ARPA broad advances in the systematic knowledge of light-element thermodynamics should come about in the next year. When this knowledge can be correlated with actual motor firings, and the results duplicated in machine calculations, a battle of two decades duration will have been won, and advanced rocket motor design will indeed have become an applied science.

—John A. Newbauer

On the calendar

1959

Aug. 31–Sept. 5	**10th Annual International Astronautical Federation Congress, Westminster, London.**
Sept. 1–2	Physical Chemistry in Aerodynamic Spaceflight Conference, jointly sponsored by AFOSR and GE MSVD, at Univ. of Pennsylvania, Philadelphia.
Sept. 2–4	1959 Cryogenic Engineering Conference, Univ. of California, Berkeley, Calif.
Sept. 9–11	Midwestern Conference on Fluid and Solid Mechanics, Univ. of Texas, Austin.
Sept. 14–15	5th Annual Conference on Titanium of New York University's College of Engineering, University Heights Campus, Bronx, N.Y.
Sept. 22–24	Industrial Nuclear Technology Conference, co-sponsored by Illinois Inst. of Tech., at Morrison Hotel, Chicago.
Sept. 28–Oct. 1	American Welding Society Fall Meeting, Sheraton-Cadillac Hotel, Detroit, Mich.
Sept. 30–Oct. 1	8th Annual Industrial Electronics Symposium, sponsored by IRE and AIEE, Mellon Institute, Pittsburgh, Pa.
Oct. 5–9	11th Annual Convention and Professional Equipment Exhibit of Audio Engineering Society, Hotel New Yorker, New York, N.Y.
Oct. 6–8	Radio Interference Reduction and Electronic Compatibility Conference sponsored by Army Signal R&D Labs at Illinois Institute of Technology, Chicago.
Oct. 6–9	Int'l Symposium on High Temperature Technology, sponsored by Stanford Research Institute, at Asilomar, Calif.
Oct. 7–8	Second Advanced Propulsion Systems Symposium, jointly sponsored by AF Office of Scientific Research and Avco-Everett Research Lab, New England Mutual Hall, Boston, Mass.
Oct. 7–9	ASME-AIME Solid Fuels Conference, Cincinnati, Ohio.
Oct. 7–9	1959 National Symposium on Vacuum Technology, American Vacuum Society, Sheraton Hotel, Philadelphia.
Oct. 12–14	National Electronics Conference, co-sponsored by Illinois Inst. of Tech., at Hotel Sherman, Chicago.
Oct. 13–14	National Technical Conference on "Plastics Engineering—State of the Art Today," sponsored by Society of Plastics Engineers at the Ambassador Hotel, Los Angeles.
Oct. 26–28	IRE Professional Group East Coast Conference on Aeronautical and Navigational Electronics, Lord Baltimore Hotel, Baltimore, Md.
Oct. 26–30	1959 National Conference of the Society of Photographic Scientists and Engineers, Edgewater Beach Hotel, Chicago.
Oct. 28–29	6th Annual Computer Applications Symposium, sponsored by Illinois Inst. of Tech., at Morrison Hotel, Chicago.
Nov. 5–6	8th Annual Instrumentation Conference sponsored by Louisiana Polytechnic Institute School of Engineering, Ruston, La.
Nov. 16–20	**ARS 14th Annual Meeting and Astronautical Exposition, Washington, D.C.**
Nov. 16–20	5th Int'l Automation Exposition and Congress, N.Y. Trade Show Bldg., New York, N.Y.

1960

Jan. 11–13	6th National Symposium on Reliability and Quality Control in Electronics at Washington, D.C., sponsored by American Society for Quality Control, IRE, AIEE, and EIA.
Jan. 28–29	**ARS Solid Propellants Conference, Princeton Univ., Princeton, N.J.**
Feb. 1–5	ISA Instrument-Automation Conference and Exhibit, Houston Coliseum, Houston, Tex.

Robbins Aviation Becomes ARS Corporate Member

Robbins Aviation, Inc., Los Angeles, Calif., manufacturer of dehydration equipment, valves, and other aeronautical equipment, has become a corporate member of the American Rocket Society.

Representing the company in Society activities are Hugh C. Robbins, president; H. N. Mabery, vice-president, sales; J. R. Clark Jr., chief engineer; and Ron H. Craton and Robert T. Bonar, service engineers.

SECTIONS

Kansas City: In June, 65 Section members and their wives toured the Neosho, Mo., plant of Rocketdyne, during which they saw the steps involved in the machining, assembly, and inspection of liquid-propellant engines for both Thor and Jupiter missiles; witnessed an impressive static-firing test of the Thor engine; and examined the firing-control center, where test data are collected and analyzed, and the test stand. The excellent arrangements for this tour made it both informative and pleasant.

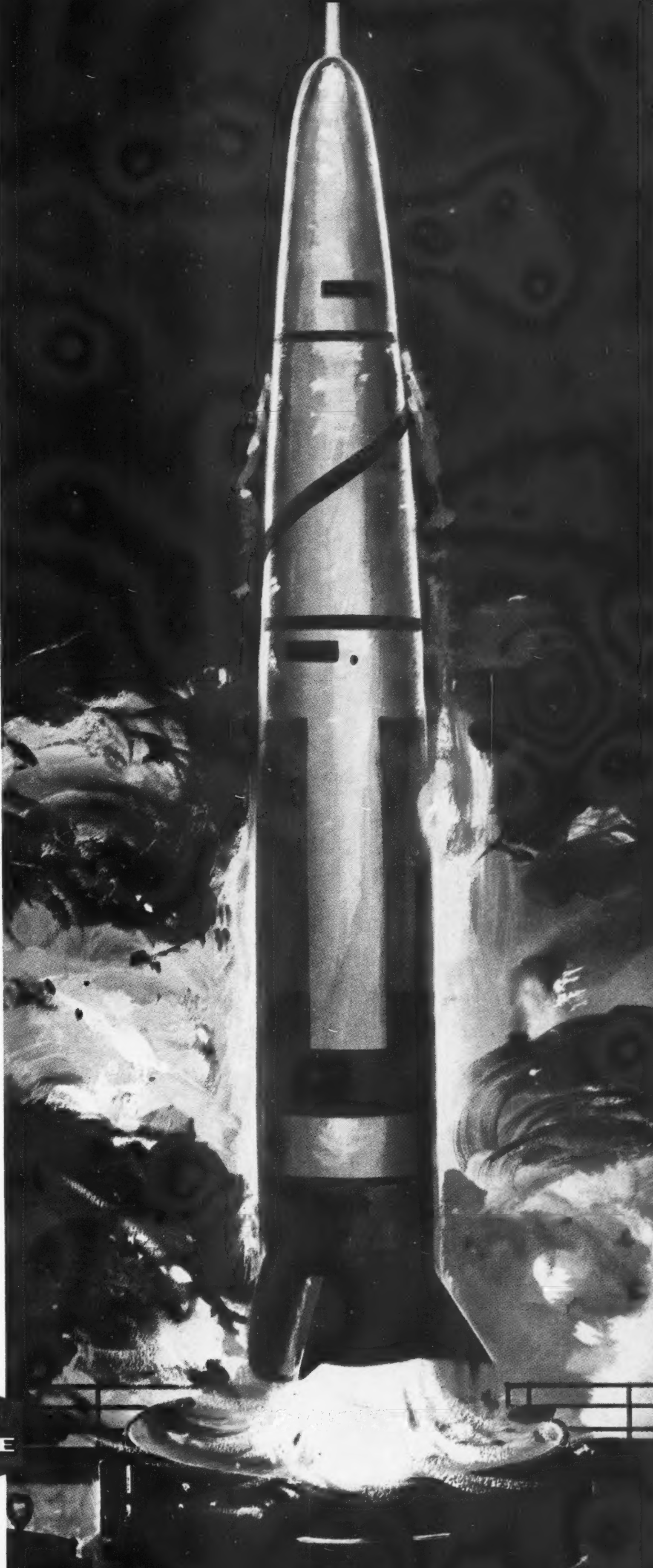
—R. W. Fetter

Maryland: At a recent meeting, the following Section officers were elected for the coming year: Harold J. Hasenfus, president; Peter A. Castruccio, vice-president; John Calathes, secretary; and Joseph P. Sansonetti, treasurer.

Sacramento: At the June meeting, guest speaker **Walter C. Williams**, chief of the NASA High-Speed Flight Station at Edwards AFB, presented an authoritative summary of the development programs leading to the X-15 rocket-powered aircraft. The speaker played an active part, beginning with the X-1 program, in directing high-speed flight tests. This background added vividness to his description of the X-15 and its mission of "fringe-of-space" research.

He pointed out that the X-15 was built with the materials and processes of today, with its development representing a high degree of evolution within the aircraft and rocket industry.

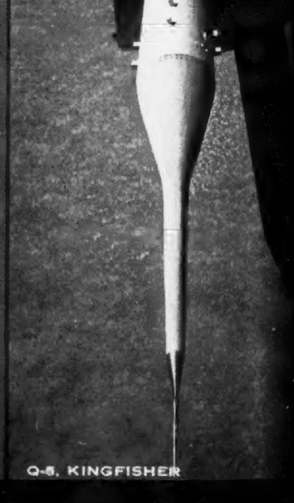
The rocket engine for the X-15 was



POLARIS FBM

DISCOVERER SATELLITE

PROJECT ARGUS



Q-5, KINGFISHER

developed by Reaction Motors Div. of Thiokol Chemical. Two versions of the engine may be used in X-15 flights. The XLR-11 engine may be used for the first flight tests, and then later the prototype XLR-99 engine. The engine employs lox and liquid ammonia propellants, regeneratively-cooled thrust chambers, and a throttle. Also, stop-restart can be achieved in flight. Safety provisions provide for idle capability, which allows the pilot to complete about 85 per cent of the starting sequence of the X-15 while it is attached to the launching B-52 aircraft. A dump system allows the pilot to use the pressurizing helium in the propellant tanks to jettison the complete fuel load. A self-monitoring feature allows the engine to "safety" itself in event of a single malfunction, and permits the pilot to try for another start of the engine in flight.

Slides were shown of X-15 aerodynamic studies and expected performance at speeds greater than Mach 5. Also, a film was shown of the first freeflight glide test of the craft.

—Ira Nagin

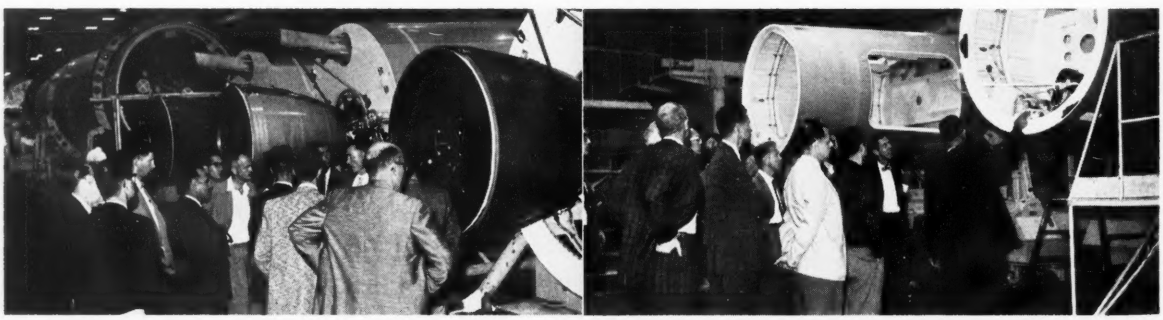
Southern California: The Section was taken on a classified field trip of Douglas Aircraft's Thor production line at Santa Monica, Calif., in June. Members were escorted in small parties through the plant by company officials, who explained the various stages in Thor production. They saw the fabrication of the missile structure, the mounting of the Rocketdyne powerplant and verniers in the boattail, the propellant lines, the mating of sections, and the control-compartment and warhead mounts. Later, Section members visited the area where the missile's trailer is produced. Then they gathered in the plant cafeteria for a talk on space vehicles. Several interplanetary missions were discussed, and the role of Thor as a booster for space vehicles was explained.

Douglas activities in the Thor program, in addition to quantity production of the missile at Santa Monica, include the operation of a static-firing facility at Sacramento, Calif. This facility permits the checking out and testing of Thor and its GSE as an integrated whole. The missile and its GSE are designed for air-transport so that it can be quickly dispersed globally.

—Eric Burgess

Utah: In June, some 200 Section members, guests, and their families were treated to a complete tour of

Southern California Section Sees Thor Production Line



Guests of Douglas Aircraft for a classified tour of the Thor production line at Santa Monica, Calif., members of the Southern California Section viewed various missile hardware and stages of assembly. Left, small groups look over Rocketdyne engine and, right, warhead-assembly section.

engineering, manufacturing, and testing facilities at the 11,000-acre research and development center of Thiokol's Utah Div.

As part of this program, **John Higginson,** general manager of the division, outlined the history of Thiokol Chemical, and explained some of the unclassified facets of its solid-propellant rocket engine program. He remarked that the Utah Div. now employs approximately 2200 people and occupies some 41 buildings.

C. S. Roberts Jr., head of projects management at the Utah Div. and president of the ARS Utah Section, told the group of planned expansion at the facility. Currently underway, he said, is a project designed to add some 5500 sq ft of floor space for engineering services.

John B. Nash, head of the Utah Div. Publications Dept., and Section director, reviewed the relatively young field of casebonded, solid-propellant rocketry which has begun to realize its potential in the propulsion arts. He commented that the program of research and development on solid propellants reflects a sincere effort to conserve defense funds.

As a part of the orientation program, the visitors witnessed an unclassified static-firing of a solid-propellant engine. They ended a busy day as guests of Thiokol for refreshments.

—**Joseph H. McKenna**

ARS Paper Deadlines

Date	Meeting	Location	*Deadline
1959			
Aug. 31–Sept. 5	10th IAF Congress	Westminster, London	Past
Nov. 16–20	14th Annual Meeting	Washington, D.C.	Past
1960			
Jan. 28–29	Solid Propellants Conference	Princeton Univ.	Nov. 30
March 23–25	Ground Support Equipment Conference	Detroit, Mich.	Feb. 1
April 6–8	Structures and Materials Conference	Santa Barbara, Calif.	Feb. 23
May 9–12	ARS Semi-Annual Meeting and Astronautical Exposition	Los Angeles, Calif.	March 21
May 23–25	National Telemetering Conference	Santa Monica, Calif.	April 1
Aug. 15–20	11th International Astronautical Congress	Stockholm, Sweden	June 15
Dec. 5–8	ARS Annual Meeting and Astronautical Exposition	Washington, D.C.	Oct. 19

*For reviewed and approved manuscripts in the New York office. Subtract 30 days for unsolicited papers that must go through the reviewing procedure and 60 days for abstracts submitted for consideration. Send all papers and abstracts to Meetings Manager, ARS, 500 Fifth Ave., New York 36, N.Y.

CORPORATE MEMBERS

American Bosch Arma will operate Ensign Carburetor Co., Fullerton, Calif., which it recently acquired, as a wholly owned subsidiary. Ensign makes equipment closely related to products manufactured by the American Bosch Div. at Springfield, Mass.

ABA was recipient of the first annual award for outstanding industrial achievement presented by the Mitchell Squadron Air Force Assn.

Baldwin-Lima-Hamilton has installed a new half-million-dollar vacuum stream-degassing facility with 15-ton capacity at its Standard Steel Works Div., Burnham, Pa., for production of low hydrogen steel rings and forgings particularly suited for high speed, high stress applications in rotating machinery.

Bell Laboratories will build a new $20 million laboratory at its 430-acre property at Holmdel, N.J., to house some 150 scientists, engineers, and other staff members working on high frequency radio and associated electronic systems.

Callery Chemical will lease part of the Sunflower Ordnance Works from the government to do certain development work on monopropellants, bipropellants, and solid propellants. According to Callery's president, E. G. Sanner, this does not mean Callery intends to enter the rocket-hardware business, but it will extend the company's testing facilities, especially in conjunction with Midwest Research Institute, which has maintained a small facility at Sunflower for several years.

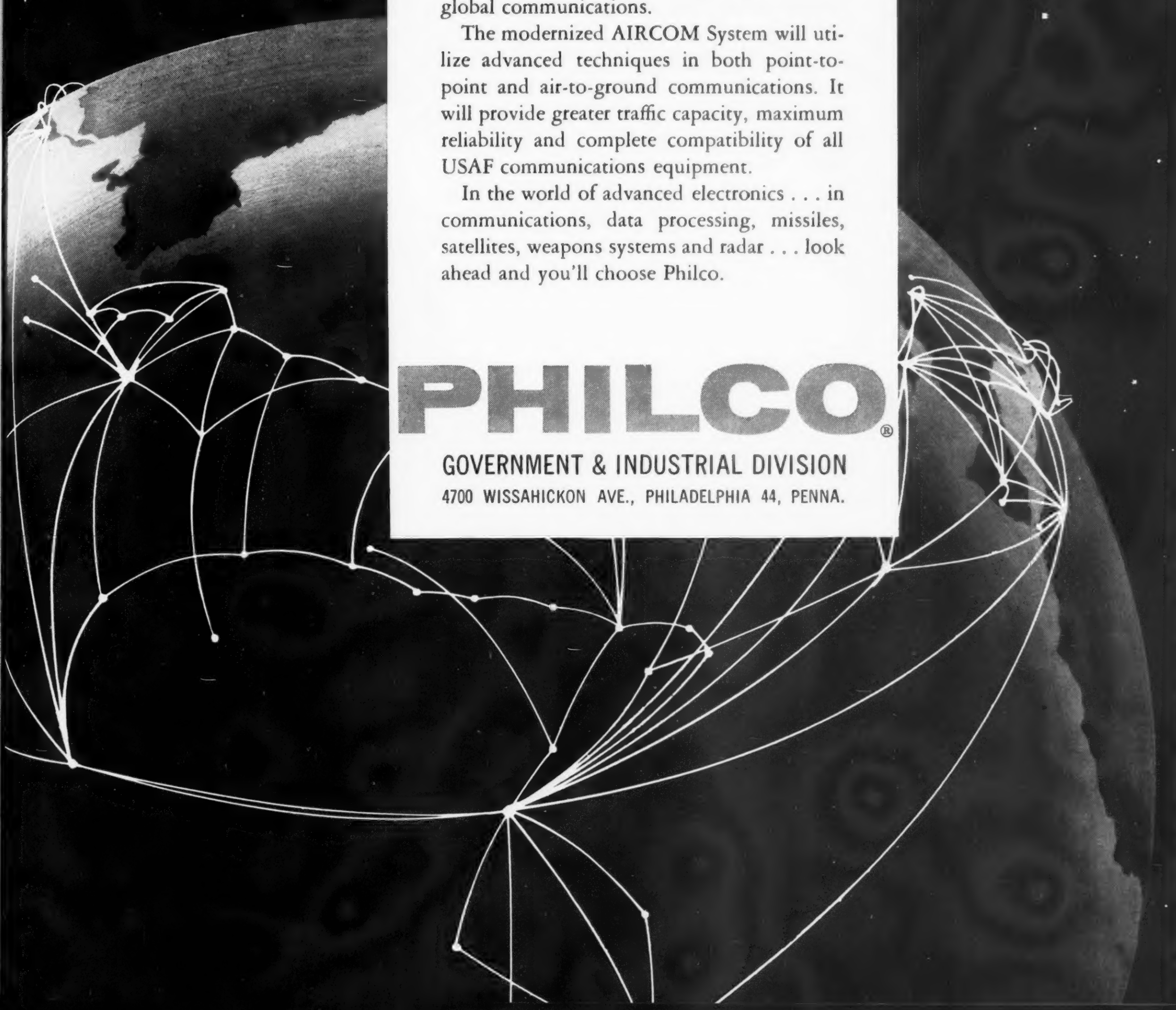
Chance Vought Aircraft has introduced a new internal organization of five divisions—aeronautics, astronautics, electronics, range systems, and research—"to take advantage of all the opportunities for success that exist in this new era of space and exotic weapons."

Fairchild's Astrionics Div. has set up a West Coast technical office in

ASTRO Covers Available

In response to a number of requests, ASTRONAUTICS is offering full-color reprints of its covers, beginning with the May 1959 issue. Reprints will be in the form of laminated plastic display plaques, with a metal D-ring on the back for easy mounting on a wall. The full-size cover, with a suitable mat, is mounted on $^1/_4$-in. rigid hardboard, with beveled edges, and over-laminated with transparent vinyl plastic. Size of the plaque is 11 by 12 in. Cost is $2.00, and only a ***limited supply*** of covers will be available each month.

The plaques may be obtained by writing to ASTRONAUTICS, 500 Fifth Ave., New York 36, N.Y.



Republic Aviation Society Fills the Gap

Lacking an organization through which to conduct local meetings, engineers and scientists of Republic Aviation at Farmingdale, Long Island, N. Y., and other industrial concerns in the area formed the Republic Aviation Society of Engineers and Scientists to discuss problems of mutual interest in missilery and astronautics. This society now has some 300 members, including most of the professional personnel of Republic. RASES requires its members to belong to a nationally recognized society, such as ARS. Responsive to situations like this, ARS is working for the formation of a section of Long Island as well as New York proper.

After speaking on guidance for modern flight vehicles before RASES, ARS member C. S. Draper, head of MIT's Dept. of Aeronautical and Astronautical Engineering, chalk ready, holds bull-session with some astronautics buffs: Sitting, A. Kartveli, head of R&D for Republic and Wm. Pappas, his assistant; standing, from left, I. Singer of Republic; R. Robertson of Systems Corp. of America; and R. Bowman and A. Bertapelle of Republic.

Hollywood, Calif., under the direction of David T. Newman, who previously headed NAMTC, Pt. Mugu's guidance lab.

Ford Motor Co.'s subsidiary, Aeronutronic Systems Inc., is adding a 120,000-sq-ft building to house its Space Technology Div. at the firm's $20 million research center going up at Newport Beach, Calif.

General Dynamics has chartered a reliability panel within the corporation to give supradivisional status to problems of reliability and to focus the attention of key scientists and engineers of the divisions on problems. The panel is a clearing house for information and a sounding board for action.

General Motor's aid to higher education program, totaling more than $5 million a year, has selected some 100 high school seniors to receive four-year college scholarships from $200 to $2000 per yr, depending upon need. They were chosen from more than 20,000 applicants from all 50 states, Puerto Rico and the District of Columbia.

The Delco Radio Div. has opened a transistor applications laboratory at Newark, N.J., to give added assistance to customers in the semiconductor field.

Hercules Powder and **Stauffer Chemical** will build their $1 million Texas Alkyls Inc. plant for the manufacture of aluminum trialkyls on a site south of Houston. Operations will be based on a process developed and patented by Karl Ziegler of the Max Planck Institute, Mulheim, Germany.

Hoffman Electronics has begun construction of a $1.5 million Los Angeles plant to double its semiconductor production capacity, with completion scheduled for Sept. 1. The facility will serve as administrative headquarters for the Semiconductor Div., now in Evanston, Ill., and for producing solar energy conversion devices.

Hughes Aircraft has contracted with nine companies for sale of its commercial products in 12 European countries. Previously Hughes announced that distributor agreements had been signed with C. Itoch & Co. of Tokyo for Japan and R-O-R Assoc. of Toronto for Canada.

Hughes has also begun a complete service for planning, designing, engineering, and building radiation facilities for industries and research institutions. This service includes applications of its Linac electron accelerator and Mobot remotely controlled manipulator.

An Announcement

ARS 14th ANNUAL MEETING and ASTRONAUTICAL EXPOSITION

November 16-20

Sheraton-Park Hotel, Washington, D.C.

Twenty-five technical sessions, five classified sessions, a Student Conference, and a glamorous exposition are thus far scheduled for the forthcoming ARS Annual Meeting, certain to be another outstanding get-together of the scientific community in the field of astronautics and related technologies. Technical sessions will cover such areas as:

Guidance and Navigation
Missiles and Space Vehicles
Propellants and Combustion
Non Steady-State Phenomena
Far Space Communications Techniques
Man in Space
Space Law and Sociology
Ionic Propulsion
Instrumentation and Control
Solid Rocket Technology
Human Reliability and Instrumentation
Logistics and Operations
Physics of the Atmosphere and Space
Astrodynamics
Test Facilities and Support Equipment
Hydromagnetics
Space Communications Equipment
Near Space Effects on Materials
Power Systems
Nuclear Propulsion
Curricula in Astronautics
Safety and Reliability of Liquid Rockets

AEC Chairman John A. McCone will address the Honors Night Dinner on Wednesday, November 19. He will speak on "The Influence of Nuclear Technology on Rockets and Space."

Hotel reservation requests should be made directly to the Sheraton-Park Hotel no later than November 2. To take advantage of a special ARS block of hotel rooms, please identify yourself as an Annual Meeting attendee on your reservation request.

ARS—Antelope Valley

(CONTINUED FROM PAGE 35)

applications in the science of rocketry and space technology. Classes were on a voluntary attendance basis, and conducted on Saturday mornings from 9 to 10:30 a.m., each class running for an hour-and-a-half without interruption. The age group spanned the sixth through eight grades and first year high school, with many parents and teachers also attending. During this year's classes, we had an average attendance of 225 students, teachers, and parents per session.

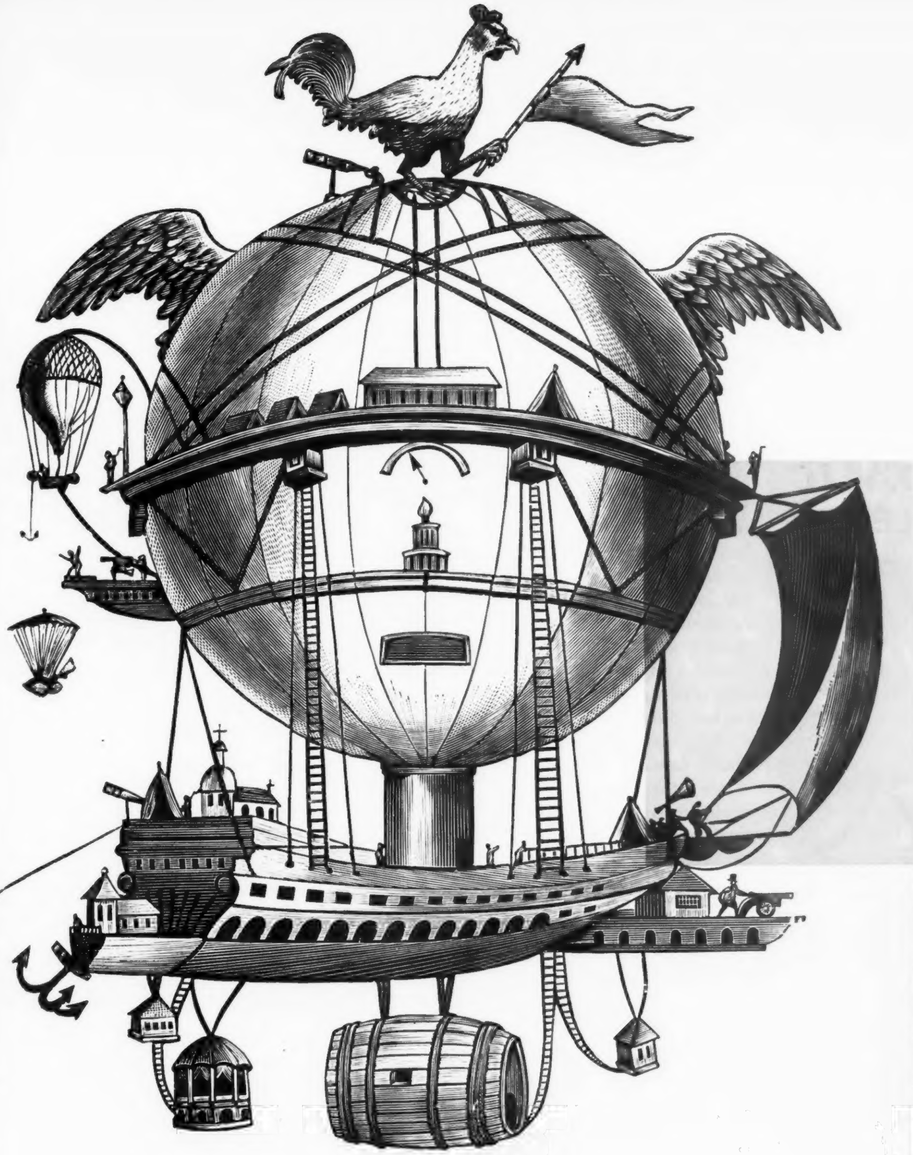
One of the most heartening things about the entire project was the cooperation we received from outside agencies. For example, before the start of the series, the local newspaper and school bulletins devoted articles to the course. The Edwards AFB Office of Information Service supplied movies, while the base Rocket Laboratory supplied demonstration equipment, functional models, and movies. The AF Ballistic Missile Div. Field Office arranged for field trips through the test facilities at the rocket base. The local school board supplied the necessary buses for the field trips, in addition to providing school facilities for the lecture series. Convair-Astronautics provided special certificates and handouts for the children who completed the entire course, while other companies in the area supplied movies and handouts.

It should be mentioned at this point that each of the classes was conducted by personnel who generously donated of their own time in preparing and presenting their respective topics.

A general outline of each class is given below to show the scope of the lecture-demonstration series:

Class 1—*Fundamentals of Physics.* The first ten minutes of this session were devoted to a general description of class material to be covered during the entire series and the introduction of succeeding speakers. A brief history of rocketry was then presented, with the remainder of the time used to explain the fundamental principles of rocketry. Demonstrations of these principles were carried out using models and blackboard diagrams, while a rocket test stand display showed how testing is conducted. Two films on the application of rockets and rocket testing were also shown. A question-and-answer period concluded the session.

Class 2—*Fundamentals of Mechanical Principles.* This class undertook to present, as a follow-up to the physics class, the principles of mechanics, with demonstrations of basic machines (lever, inclined plane, wheel, axle, etc.) and examples of how each



M. Marey Monge made no attempt to keep imagination in check when he conceived this military balloon in 1800. Complete with sail, the "dream" balloon was supposed to support an army of 4,000 in every way for months at a time. In this wood engraving, Brussel-Smith has included the most minute details of Monge's ambitious project.

contributed to modern technology.

Class 3—*Fundamentals of Chemistry.* The entire class period was devoted to explanations and demonstrations of chemistry fundamentals. Topics included atomic and molecular structures; combinations of molecules; and gases, liquids, and solids, and their characteristic differences. Some very interesting demonstrations utilized liquid nitrogen and dry ice to illustrate thermodynamics. Considerable emphasis was placed on the hazards involved in "do-it-yourself" experimentation and the indiscriminate handling of chemicals. A short movie on chemical explosions concluded the lecture.

Class 4—*Fundamentals of Electricity and Magnetism.* This lecture undertook to provide students with a basic understanding of the principles of electricity and magnetism. Explanations were pointed toward the use of these principles in the field of electronics and electrical instrumentation. Demonstrations showed how electronic instrumentation is used to gather rocket data by telemetry. A model rocket thrust stand on which a small Jetex rocket was fired demonstrated these principles as used in full-scale testing. A model telemetry station was also displayed. A short movie on instrumentation and telemetry concluded the session.

Class 5—*Fundamentals of Mathematics.* This was one of our most interesting presentations, covering the history of mathematics, how measurements began, how we calculate today, modern applications of mathematics, and the importance of mathematics in rocketry and spaceflight. A short demonstration of mathematical tricks and paradoxes evoked considerable questioning. Emphasis was placed on the application of mathematics courses as stepping stones to the other sciences, and how all science is related to this topic.

Class 6—*Astronomy.* This class was designed to stimulate an interest in studying this fascinating subject because of its new prominence in modern science. Demonstrations illustrated the natural laws of the solar system, while a movie from the Moody Institute of Science illustrated basic astronomical principles.

Class 7—*Fundamentals of Atomic Physics and Nuclear Energy.* The fundamentals of atomics physics, and what nuclear energy is, where it comes from and how it is used, were presented to the students. Demonstrations were designed to show and prove to the students that these are real and fascinating sciences. Emphasis was placed on obtaining a good fundamental background in mathematics, physics, and chemistry before undertaking detailed study of these topics. This class ran overtime because of the considerable number of questions and answers the lecture generated.

Class 8—*Tour of Edwards AFB Rocket Test Facility.* The entire class was taken on a tour of the facility to see the liquid gas manufacturing plant, a typical rocket test stand and its complex control center, and the base engineering laboratories.

Class 9—*Certificate Award Ceremony.* After a brief summary, which again stressed safety principles, certificates were presented to students who had attended all the classes. Along with the certificate, each student was given several missile pictures and a pamphlet on atomic energy as mementos of the class.

The effort put forth by the individual instructors in presenting these topics was quite extensive, and the scope of the entire series may appear to be too great for others to attempt. However, we who conducted the classes feel that the benefits gained from promoting safety and science, and the personal satisfaction each of us derived from the course, far outweighed the difficulties involved in setting up the program.

While the project has been carried out thus far by an unofficial group from the ARS Antelope Valley Section, the Section's officers and board are now considering full backing and participation in this highly successful local education program. ◆◆

ARS—Colorado Section

(CONTINUED FROM PAGE 34)

organizations may have with ARS is through committees of this kind. Thus it is important to make sure committee operation is smooth and well coordinated, that it knows what it is doing and can follow through on its activities. Only in this way can it sell the Society and its aims to the organizations with which it comes in contact. Present committee structure (shown on page 34) is regarded as ideal for its type of operation.

Broad horizontal organization puts a premium on lateral coordination, especially for special projects. A one-shot lecture engagement requires, in addition to selection of a topic and qualified speaker, the collection of training aids and coordination of the particular appearance with the over-all program. Continuous supervision of a school project presents a variety of special requirements. The inclusion of legal and insurance authorities within the committee assures ready access to such specialized counsel. In

90 seconds of inferno

A rocket engine capable of more than 50,000 lbs. of static thrust, developed and built by Reaction Motors Division of Thiokol Chemical Corporation, will soon send the fabulous X-15 searing into outer space. To protect the engine from its own fierce blast, key metal surfaces are coated with ROKIDE "Z" coating.

... but ROKIDE* Coating will protect the X-15's engine during critical burning time

As the manned X-15 bores into the sky for 100 miles or more in its forthcoming tests, rocket-powered flight will last only for about a minute and a half. However, protecting the engine from the tremendous heat and erosive force of its propellants for even that brief span posed a major design problem. Engineers solved it by coating critical metal surfaces with ROKIDE "Z" zirconium oxide — one of today's most rugged refractory materials.

This is typical of the new and challenging requirements which all three types of hard, crystalline ROKIDE spray coatings ("A", "ZS" and "Z") are meeting in the ever-expanding air and space programs. These outstanding members of Norton Company's large family of refractory materials, as well as other experimental coatings such as chrome oxide, spinel, etc., are providing protection against high heat and abrasion, corrosion and severe thermal shock in supersonic aircraft, missiles and rockets.

Norton Company maintains ROKIDE coating facilities on both coasts: at the main plant in Worcester, Mass., and at its plant in Santa Clara, California. For details, write NORTON COMPANY, Refractories Division, 966 New Bond St., Worcester 6, Massachusetts.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

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NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — BEHR-MANNING DIVISION Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

addition to avoiding many administrative pitfalls, such authorities lend weight to recommendations deterring live rocket experimentation.

The operational goals of the Central Colorado Committee were established in the spring of 1958. They included sending letters to all civic associations and educator groups offering ARS presentations for their meetings; publicity for rocket activities within the local area, including public invitations to attend ARS Section meetings; and, last but not least, a continuous program of instruction and monitoring of student groups represented a large part of the projected program.

Initial contact with active rocketry groups stressed the ARS policy discouraging live rocket experimentation. Letters sent to known clubs and groups urged registration with the Society, and offered guidance and assistance in club projects and goals. All participants were asked to join in a general program aimed at discouraging hazardous experimentation and to assist in bringing the weight of public sentiment behind this effort.

The original information program plan called for the establishment of a series of lectures to be made available to groups and organizations responding to the introductory letters. The responsibility for the formulation of this series was undertaken by the Education Series Subcommittee. The Community Relations Subcommittee continued to elicit interest by providing followup information on the scope of the program to organizations which had already been contacted. Local sources at the Martin Co., the Air Force Academy, and Lowry Air Force Base were investigated by the Plans and Programs Subcommittee to determine the availability of training aids and ancillary materials. The end product of coordinated committee effort provided the requesting organization with a presentation tailored to individual requirements and based on the interest involved. From single lectures and addresses for civic groups to extensive lecture and discussion series for university student and faculty consumption, the underlying consideration was the ultimate channeling of active interest in rocketry into undertakings conforming to ARS standards and goals.

Radio and TV Coverage

The most ambitious aspect of the publicity program was the projected radio and TV coverage sought in conjunction with local stations. The ultimate aim is for a series of educational presentations. Several stations were approached on the basis of an hour-long trial program to ascertain feasibility and public acceptance. TV is the strong preference. It is clearly the most satisfactory medium due to the greater possibilities for continuous and varied presentation.

Focus on the area of most active interest led to negotiations with nearby Colorado Univ., Colorado School of Mines, and Denver's East High School. All had groups of students whose interest in rocketry ranged from casual interest as a hobby to those who were contemplating careers in space technology. This latter group presented the committee at the very outset with a challenge through the oft-repeated question: "What should I study to become a rocket engineer?"

Trial programs conducted at the two universities were designed as a partial answer to this question. A series of 15 lectures was given at each institution. The lectures were an hour long and were followed by discussion and a question-and-answer period. The scope of the series embraced the entire field of space technology, giving the students an insight into its many and varied facets. Airborne subjects included aeronautics, avionics, and propulsion systems. Ground support equipment was covered by lectures on systems, hardware, electronics, and R&D. Space travel and space medicine came under the heading of space applications. Speakers were drawn predominantly from Martin Co. members specializing in a particular subject. Audiences numbered up to 150 students and faculty advisers.

The program at the East High School was on a smaller scale, but no less provocative. A group of 50 selected students, together with faculty representation, attended an introductory lecture which covered the whole range of rocketry subjects. Following a discussion period, the group divided into three sections for more detailed presentations on space travel, space medicine, and propulsion systems. Further inquiry into these subjects and intergroup discussions were to follow under faculty and ARS guidance.

Enthusiastic Reception

The reception of these trial programs was uniformly enthusiastic in the three schools. Particularly among university students it was felt that the approach taken by speakers actively engaged in the field contrasted effectively with the more academic approach of the regular school curriculum. Faculty members commented that the speakers were exceptionally well informed and agreed that the program was one of the most beneficial and educational of the school year. In many cases, the programs were judged by students to be more informative than the regular curriculum.

By the end of the lecture series, the need for student guidance activity warranted a two-fold approach to the career study question. Conferences were held with appropriate staff members of the Univ. of Pennsylvania, Drexel Institute of Technology, and the Martin Co. to decide on an optimum course of study in rocket engineering. The lecture series had indicated to the students the complexity of the science and the impossibilty of covering its many branches in one major course. These conferences attempted to determine what skills and knowledge were basic to all engineering disciplines in the field.

The other approach taken to student planning recently inaugurated by the Section is a "buddy system" of career guidance. Each student is paired with an active ARS member, usually on the basis of a selected branch of the rocket sciences. Though still in the embryonic stage, this system already shows great promise in making available to the student advice and insights into the working aspects of his selected field. Eventually, such associations can form an effective means of supervision for study and research in conjunction with club activities.

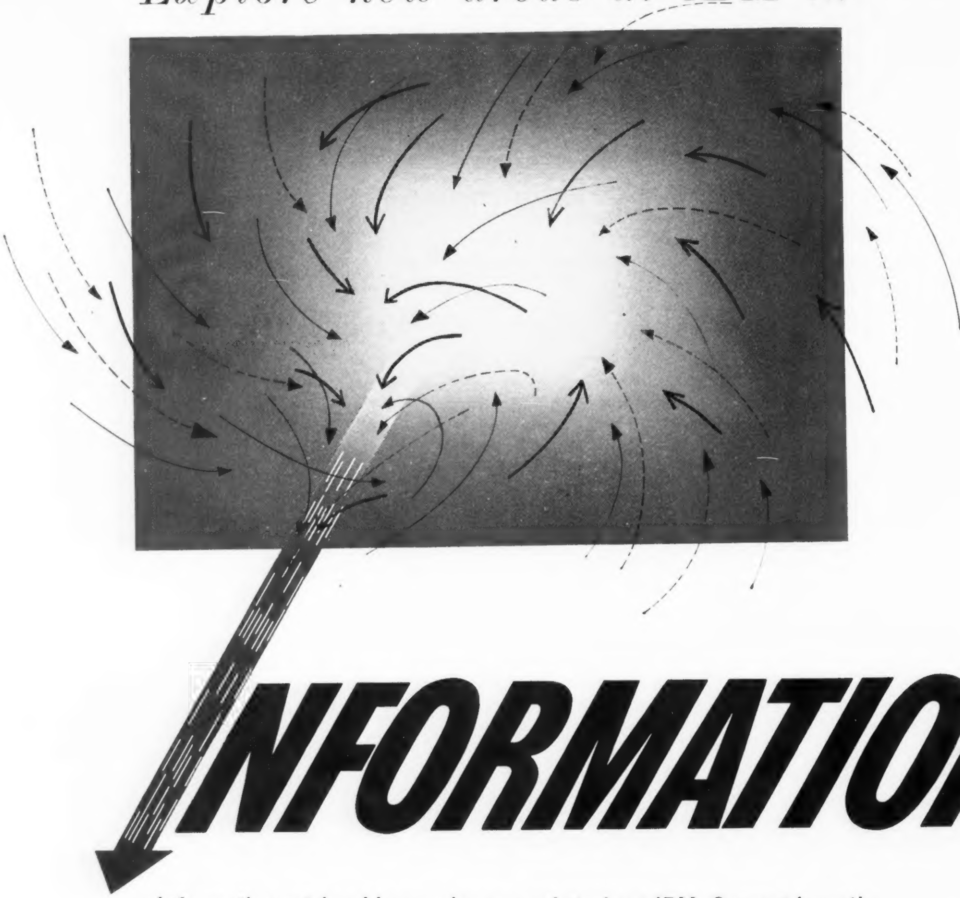
The success of the trial programs in the two universities has assured their repetition during the coming school year. Minor modifications will be made in conformance with studies of

Houston Navy League Sponsors Field Trip For Science Students

Larry F. Megow of Hahn & Clay, Houston, Tex., the motivating force behind the soon-to-be-chartered ARS Houston Section, was also one of the prime movers behind a recent field trip sponsored by the Houston Council Navy League, which took 35 of the top science students in the area to the White Sands Missile Range and the AF Missile Development Center, Holloman AFB.

In the course of the three-day trip, the students had a chance to view a rocket sled run on the 35,000-ft Holloman test track, and to watch Talos and Honest John launchings. They were also taken on a full-scale tour of the Holloman and White Sands facilities.

Explore new areas at IBM in



INFORMATION

Information retrieval is a major area of study at IBM. Current investigations may lead toward such benefits as the instant accessibility to knowledge in scientific libraries throughout the country—or toward a system which can translate any of the earth's languages into English in real time.

Problems in information retrieval have defined entirely new concepts for the design of storage, input-output and "memory" units—achieving far greater capacities than any known today. These facilities will provide for the handling of the tremendous amount of updated information needed by business, science and government. With extremely rapid accessibility to vast amounts of information electronically stored by machine, industrial and research efforts can be materially expedited. IBM needs engineers and scientists with the vision and the ability to pave the way to tomorrow.

You will enjoy unusual professional freedom and the support of a wealth of systems knowledge. Comprehensive education programs are available plus the assistance of specialists of many disciplines. Working independently or as a member of a small team, your individual contributions are quickly recognized and rewarded. This is a unique opportunity for a career with a company that has an outstanding growth record.

audience reaction as well as suggestions from students and faculty. The Air Force Academy has asked that a program be available for presentation to a select group of cadets this fall. Other university groups in the area have expressed a similar interest. A more extensive program is planned for the Denver high schools based on the considerable encouragement resulting from the first presentation.

As these student education programs continue and expand, they must constantly be reviewed to keep abreast of student knowledge and interest. In consonance with the general aims of the ARS, present emphasis is on nonhazardous research projects, carried out on an intra- and inter-club basis. Optimistically, it is foreseeable that experiments and papers of definite scientific value will be the end product of such activities. If the ingenuity and energy presently expended on live rocket experimentation are any indication, the realization of such a goal may occur in the not too distant future.

In addition to the student development program, a parallel activity aimed at heightening public awareness of the rocket sciences is also beginning to bear fruit. A preliminary agreement for the production of a TV show has been completed with local Denver station KRMA. Pending feasibility from the cost standpoint and approval of the program idea, it is expected to be ready this fall. The increased number of requests for presentations to local agencies and organizations are being met through the use of excerpts from the university lecture series and specially planned programs where specific interest is indicated.

To date, the organization of the committee and its activities has proceeded along lines dictated by local resources and conditions. Ready availability of raw materials in terms of qualified speakers, facilities, and aids, plus a public interest already quickened by the operations at nearby Martin-Denver, have permitted a broad and ambitious beginning. Though many of the problems incurred are of local origin, their solution lies with the backbone of any working group and the enthusiasm and imagination of its members—a resource shared by all ARS Sections.

As similar programs are instituted in different parts of the country, problems common to all Sections will be encountered. One of major importance will certainly be in the career guidance area. Machinery should be instituted on a national level to assure the validity and uniformity of the answers and solutions in conformance with ARS policies and aims. ◆◆

Missile market

BY JEROME M. PUSTILNIK, Financial Editor

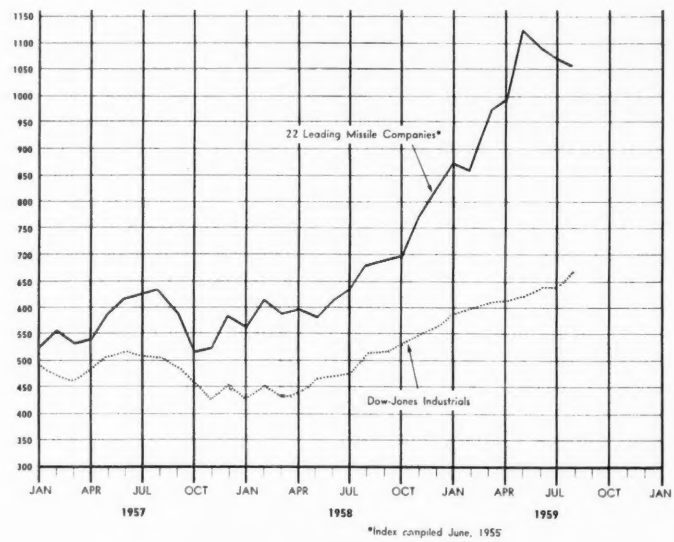
DECLINING for the third consecutive month, the Missile Index slipped 1.1 per cent in August. While this continuing erosion of market prices can hardly be encouraging, it may be meaningful that the rate of descent has eased each month. Perhaps an end to the correction of the Missile Index's sharp January through April advance is at hand.

Meantime the stock market, aided by a flood of unexpectedly good second quarter earnings reports, sailed to a handsome gain of 4.8 per cent last month as measured by the Dow-Jones Industrials.

In this context, a recent survey reported that the aggregate earnings of 10 leading aircraft manufacturers plummeted 61.8 per cent during 1959's second quarter, compared with the corresponding 1958 period. In vivid contrast, profits of 428 other companies in varying industries soared 75.6 per cent. Little wonder, then, that the aircraft sector of the Missile Index consistently has been weak.

Nonetheless, this column believes *Martin Co.* and *Northrop Corp.* are attractive investments at this time, as two of the few aircraft companies likely to report earnings gains in 1959. This month's column will discuss Martin Co., leaving Northrop for next issue.

THE MARKET AT A GLANCE



	August 1959	July 1959	% Change	August 1958	% Change
Dow-Jones Industrials	675	644	+4.8	505	+33.6
Missile Index	1059	1071	−1.1	678	+56.3

One of the first companies to recognize the shift in weaponry from aircraft to missiles, Martin has become a leading missile manufacturer. Electronic systems and missile sales accounted for almost 59 per cent of 1958's volume, with aircraft sales contributing 41 per cent. Furthermore, orders for missiles and electronic systems constituted 72 per cent of Martin's $832 million backlog on December 31, 1958.

Prime contractor for the Titan, the hardbased second-generation ICBM now well into its test-flight program, Martin also produces the Bullpup, an air-to-surface solid-fuel missile specifically designed to support ground troops with nonnuclear firepower. Other Martin missiles are Lacrosse (a field artillery guided missile controlled by a forward guidance station) and Mace (a tactical surface-to-surface guided missile that is replacing its forbear, Martin's Matador). The company also is weapons systems contractor on Pershing, the Army's solid-fuel ballistic missile which is being developed under a major R&D contract. In yet another missile area, Martin's Missile Master is the first fully operational electronic control system which coordinates anti-aircraft missile batteries. Several systems already have been installed, and important additional business is anticipated.

The P5M-2 Marlin, the Navy's antisubmarine flying boat; the P6M multijet Seamaster seaplane; and subcontract work on McDonnell's F-101, constitute Martin's aircraft line.

Many company activities look to the future. The Nuclear Div. has developed and demonstrated a radioisotope-fueled thermoelectric generator, in addition to winning a contract to produce a portable nuclear powerplant for the Air Force. Although this division's sales are only about $4.4 million, these programs place it in the forefront of important new technologies. As head of one of the two competitive teams developing plans for Dynasoar, the boost-glide orbital bomber, Martin could receive substantial business if its group were selected. RIAS Div. performs basic scientific research for the company.

Up-to-date plants and facilities implement these programs. During the last three years, new missile plants at Denver and Orlando have been built and staffed, and the Baltimore plant completely modernized. An integrated missile facility, the Denver plant can transform an engineer's line drawing into a complete weapon system, handling design, fabrication, and captive testing on one of the four giant firing stands. At the Orlando plant, which employs almost 7000 people—one out of four a graduate engineer or scientist—more than 60 per cent of activity is in advanced electronics, and this is expected to reach 90 per cent within the next five years. Both plants are expanding.

As many of its programs grow swiftly, Martin's 1959 sales easily should exceed 1958's record $483.6 million despite declining aircraft production. And with earnings of $2.12 a share reported for the first 6 months

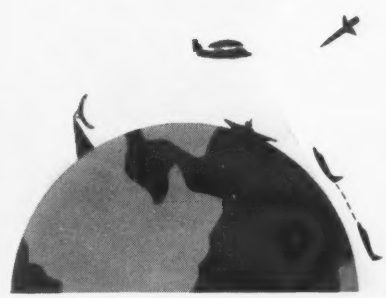
(CONTINUED ON PAGE 94)


NAVY
18
GRUMMAN AIRCRAFT ENGINEERING CORPORATION

PEACE TAKES A LOT OF WATCHING!

Low-flying "enemy" aircraft or missiles are undetected by ground radar because, as the diagram shows, the range of ground-level radar extends no further than the horizon.

Detection range is increased appreciably when the radar detection equipment is airborne directly over the ground installation.



The scope and effectiveness of radar detection are extended dramatically with WF-2's operating off fast, mobile and far-ranging aircraft carriers at sea.

That's why the U.S. Navy will send eyes aloft to scan the seas and skies beyond our shores. The eyes, with this special kind of vision, are early warning aircraft. Many will be WF-2 "Tracers", produced for the Navy by Grumman.

WF-2's "see" via a saucer-shaped radome that houses super-sensitive, long-range electronic detection equipment. Operating from aircraft carriers far out at sea, "Tracers" patrol the extremities of our defense perimeter. And, detect the approach of aircraft or missiles that might invade the privacy of a nation's peace.

Bethpage · Long Island · New York

Grumman

Sociology and the Space Age

(CONTINUED FROM PAGE 37)

tion known to the author will commit funds for a temporally indefinite venture such as this, in which repeated studies would be necessary in order to define attitudes, opinions, and beliefs only a short time before the actual event took place.

It is crucial to note, however, that *after* the occurrence of manned spaceflight, it is simply too late to test rigorously any hypotheses regarding the effects of the space age on mankind. The same problem has plagued disaster researchers who, for similar reasons, can gather only second-best data after a disaster has occurred. A survey of the type we are discussing does have one advantage over disaster methodology, in that we *know* manned spaceflight will occur, while disasters can not be predicted with any degree of accuracy.

A survey of this kind represents an opportunity we cannot afford to miss, both for the sake of present and future behavioral scientists. How much more might our knowledge of human behavior have been advanced had our ancestors in the days preceding the voyage of Columbus, or prior to the coming of the Reformation, or on the brink of industrialization, assembled *systematic data* on the state of mind of humanity at such strategic junctures of history! Today, we have both the methodology and the substantive knowledge to do this. We are, for the first time in history, equipped with tools permitting us to analyze the course of a major social revolution as it unfolds before our eyes.

The historian 100 years or so from now would be justly amused by the fact that we provide him with data on dating habits of college freshmen (in a particular school at a particular time), or even on the number of men and women in a nation—but with little systematic information on the forces which shape history.

The second major question revolves around the effects of the space age on the social structure. The complexity and newness of astronautical operations have generated new social roles, new statuses, and new organizations (or man-machine systems).

Thus, from the standpoint of basic research, the space age provides us with an opportunity to study the processes of delineation and reformulation of social roles. What attributes will actors in these new roles have? How is their performance defined? How are these new roles and statuses placed into the existing social system? The emergence of a possible new elite class implies displacement of other elite classes. Which ones? And with what consequences?

Hitherto connected closely with the development of modern weapons systems, space technology has led to the introduction of a number of new occupational specialties. But, in contrast with the emergence of specialties in the past, the *social visibility* of these role-actors is low. The uninitiated do not quite know what such individuals are doing, or how. What constraints are generated upon the interaction involved in research, development, and launching of spacecraft?

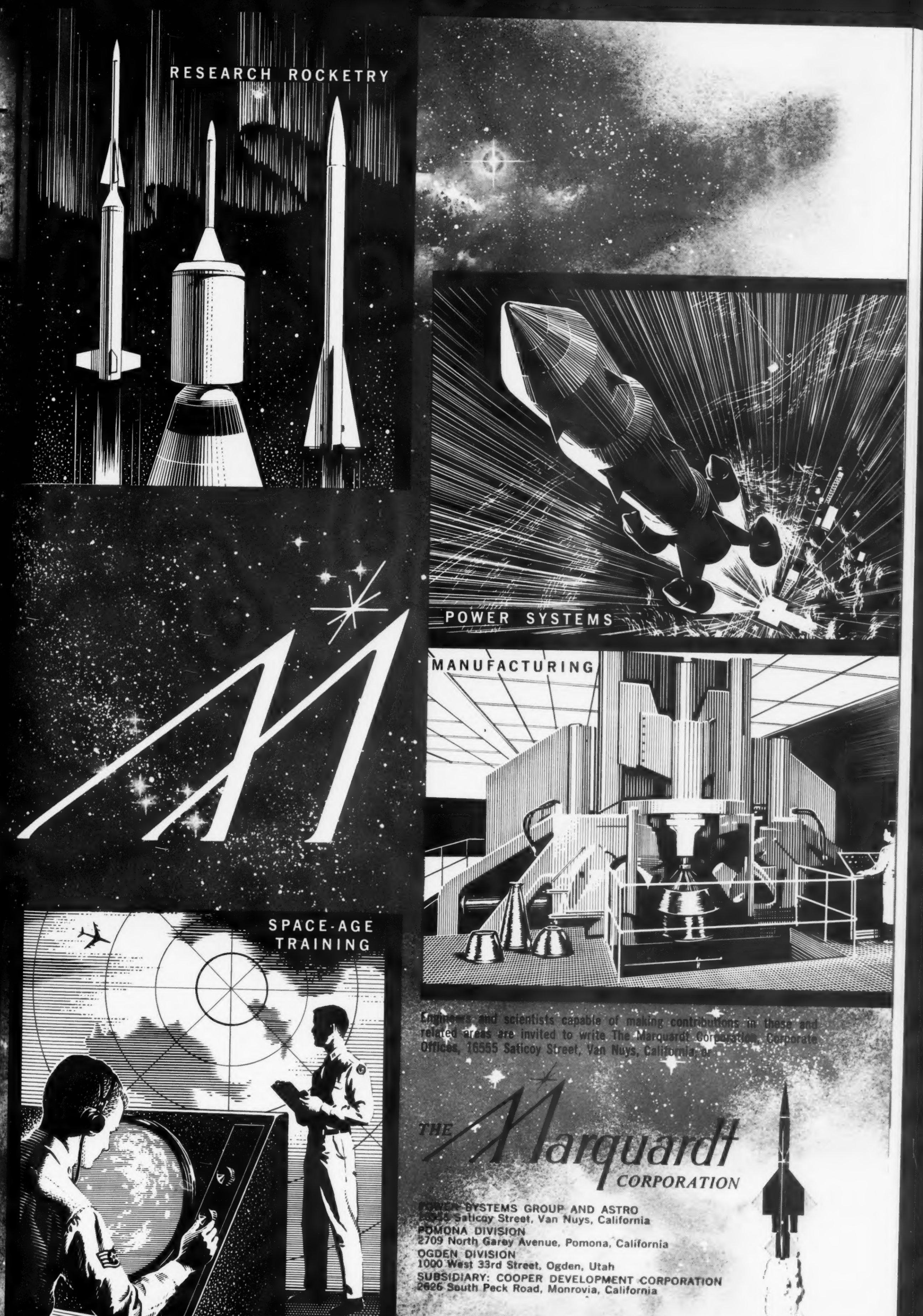
From the viewpoint of operational research, answers to such questions may well lead to an understanding of the stresses and strains peculiar to the man-machine systems of the space age. From the vantage point of basic research, much can be learned about the importance, and consequences, of visibility both in terms of psychological and sociological dynamics.

If high status in the community at large were attributed to the actors in space systems (not only to those who man the vehicles), is this partly because of low visibility? If so, then the disequilibrium with respect to, say, a semiskilled worker associated with a spaceport, is considerable. Within the system that counts (the spaceport), his status would probably remain fairly low, but outside the system, it might be high.

Effects on Science

Next, consider the effects on science and scientists of increased public interest and information. If advancement in space technology is an aspect of national defense effort and mirrors, to an extent, competition with the Soviet Union, pressures to succeed might well be both considerable and increasing. Yet overemphasis on success is often detrimental to succeeding. "Safe" courses of action (in which risks are minimal) tend to be chosen in preference to creative chances.

Another set of problems revolves around the effects of the space age upon international affairs. Only one issue will be mentioned at this time. It would seem that unless manned spaceflight is a cooperative international venture, the area over which subsequent agreements can be reached is extremely limited. With regard to manned space exploration, negotiations at the present time would begin from a basis perhaps most conducive to reaching agreements—relative equality of Soviet and U.S. accomplishments. Questions of priority, pride, etc. will occur with successful manned spaceflight on the part of either the Soviet Union or ourselves. Disequi-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Engineers and scientists capable of making contributions in these and related areas are invited to write The Marquardt Corporation, Corporate Offices, 16555 Saticoy Street, Van Nuys, California; or
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2626 South Peck Road, Monrovia, California

librium around any negotiating table is created, and the relative bargaining positions of the competitors is greatly modified.

If we look inside the manned spacecraft, other problems arise. At some point, crews rather than individual astronauts will travel into space. Bordering on the obvious is the fact that the sociology of small groups may have quite a contribution to make. The selection of individual astronauts can be carried out almost entirely in terms of medical and psychological parameters, but the selection of *crews* presents somewhat different problems. For one thing, there are crucial issues of optimal division of labor on board a spaceship which, in turn, specify requirements as to characteristics, skills, and knowledge crew members must have. Secondly, there are issues of lines of authority and interpersonal relationships in general. If each member of a crew is sent (at least to start with) due to his indispensability, it is not all clear how a chain-of-command system can be devised short of carefully experimenting with alternatives. From the standpoint of interpersonal relations, numerous findings of social psychologists and sociologists indicate that the five best astronauts do not necessaily make the best crew!

Thirdly, it is far from obvious that, under conditions of severe sensory deprivation, interpersonal systems will respond in the same manner as individuals of which they are composed. In fact, it is highly unlikely that they would. Various social pressures come to bear upon crew members to conform to emerging norms of spaceflight —whether to show fear and how, whether to show courage and how, whether and when to display elation or not, whether to gripe or not, etc. None of these problems is characteristic of flight by individual astronauts, who can behave much as they please. All, and many more, however, are factors to be considered for team flights.

Fourthly, it is important to realize that the first few spaceflights will have consequences for the pattern of space travel far beyond their own immediate significance. Specifically, a new tradition is going to emerge with its peculiar language, habits, customs, and mores which will become progressively more difficult to alter.

The atomic submarine provides as good an analog as we can currently think of. But differences are quite considerable, and direct application of data from submarines to spaceships is difficult. The Navy does have a tradition for the selection of submariners; the submarine as a system has its norms well-established. New submariners get socialized into such norms, whereas members of spacecrews will, to start with, have to develop them by their own interactions.

Thus, it seems desirable to conclude by stressing the strategic importance of a major simulation facility for the systematic study of problems related to crew selection and crew behavior during spaceflight.

Selection Is Difficult

Apart from crews of spaceships, we must take into account the more permanent forms of space exploration. Presumably, stations and settlements of various kinds, sizes, and compositions will result at some point. Again we deal with issues of selection as a function of the purposes of such settlements—military, scientific, or combinations thereof. What are the requirements as to size? Distribution of skills? Knowledge? What are the consequences of varying size, skill availability, knowledge availability?

Once more, a new tradition is in the making, not independently of what is known about formal organizations but adaptive to conditions to be encountered. Before space travel becomes common, new social systems will likely have already emerged. Much light can be shed, it would seem, on various basic theoretical questions related to frontiers and frontier life. But again the differences can not be underestimated. The settlements will tend to be composed of members well-integrated into their own society, rather than of migrants deviant in terms of their culture or their time, such as persecuted political or religious minorities. Experts and specialists will predominate, in contrast with the early migrants into newly discovered continents or areas.

Next, consider the impact upon each other (and on this planet) of multinational settlements on another planet —for instance, the co-existence on Venus of Soviet and American settlements. What conditions might lead to a Venusian identification—and thus convergence of interests of initially hostile settlements, even if hostilities were maintained on earth? Can we expect, as I think we can, the growth of autonomous thinking and acting in such settlements resulting simply from the fact that the day-to-day problems of such settlers could not be answered meaningfully from Washington or Moscow? Much too frequent transfers back to this planet would render the social system unstable; infrequent transfers would tend to render it increasingly independent.

These are problems deserving of study. Much as we need a global census of attitudes, opinions, beliefs, and goals to assess changes resulting from man's entry into the Cosmos, and a *simulation facility* to study variables of selection of crews and their behavior during flight, another *simulation facility* is necessary to develop research programs pertaining to *problems of settlement*.

In addition to the requirements for careful theoretical analysis on the basis of our knowledge of social behavior to date, and the resulting identification of crucial problems for further study, three specific proposals are implied in this discussion:

1. To carry out a worldwide (or at least national) census of opinions, attitudes, beliefs, and goals of humanity *prior* to the entry by men into space, thus enabling us to trace the course which this gigantic social revolution will take.
2. To carry out systematic experiments in the area of crew selection and behavior during spaceflight in a simulation facility very much like space vehicles of the future. This, in turn, will provide data for the development of vehicles which minimize stresses on the interpersonal systems involved.
3. To carry out systematic experiments in a simulation facility of space settlements and space stations.

These proposals represent the broad goals for a minimal research program in space sociology. It is feasible as well as desirable.

Based on a paper delivered at the ARS Space Law and Sociology Conference in New York City on March 20, 1959. ◆◆

Have Aeropak, Will Travel

Development engineer shows off Aerojet-General's variable-thrust one-man rocket, the Aeropak. Operator's left hand controls angle of thrust; right hand holds throttle. Such an engine might be used by foot soldiers and rescue workers.

In print

The Challenge of the Space Ship by Arthur C. Clarke, Harper and Bros., New York, 1959, 213 pp. $3.50.

Arthur Clarke is what might be described as "the thinking man's writer" in the field of astronautics. Already the author of several excellent books for the layman on this subject ("Interplanetary Flight," "The Exploration of Space," "The Making of a Moon," etc.) and of some of the most provocative science fiction of our time, in this—the first collection of Clarke's scientific and speculative articles—he turns his attention to some of the more profound implications of spaceflight and also explores a number of areas on the borders of present knowledge.

Nontechnical in nature, these articles still manage to provide the reader with a good deal of basic information on satellites, interplanetary journeys, the moon, sun, and Mars, radio astronomy, and a host of other subjects, in as painless a manner as possible.

The title article (based on a talk given some 13 years ago during the author's first term as president of the British Interplanetary Society) and the chapter entitled "Across the Sea of Stars" discuss with much wisdom and wit the impact on humanity of the space age. In "The Planets Are Not Enough" and "Where's Everybody?" Clarke takes up the problem of interstellar travel, and in the latter he investigates the question of why, if there are other intelligent beings in the universe, we have not as yet had any visitors from space. "Things in the Sky" takes a good look at UFOs and concludes that most of them, contrary to their name, *can* be identified without too much difficulty.

"Of Mind and Matter" considers the effects of recent electronic research and its implications in terms of the identity of the individual and survival after death. "Of Space and Spirit" offers a consideration of the insignificance of man and earth in the cosmic sphere in the light of the new concepts of time and space which have developed in recent years.

Nor has the author's light touch, which has made so much of his science fiction fun to read, deserted him. In "Report on Planet Three," he supplies us with a view of earth as seen through the eyes of a Martian astronomer, who sums up his observations with the inevitable conclusion that "our neighbor earth is. . . certainly quite unfitted for any type of life which now exists on Mars." Three lighthearted chapters provide a rundown on life at a satellite motel, on the moon, and on Mars in the 21st century, while "Question Time" provides an insight into the types of questions a popular lecturer on astronautics is faced with on his tours. "Oh for the Wings. . ." discusses the possibility of man's being able to fly by means of his own power, and suggests a fascinating new sport of the future.

Like other Clarke books, this one is must reading for his host of admirers.

—**Irwin Hersey**

Rocket Encyclopedia Illustrated, edited by John W. Herrick and Eric Burgess, Aero Publishers, Los Angeles, 1959, 607 pp. $12.50.

Some five years in the making, this impressive volume forms an excellent counterpart to the recently published Van Nostrand "Dictionary of Guided Missiles and Space Flight," edited by Grayson Merrill. In fact, between the two, there is little likelihood that anyone searching for a definition, a particular photo or illustration, a formula, or a chart will fail to find it.

This large-format (7 $^3/_4$ by 10 $^3/_4$ in.), well-illustrated book provides thousands of definitions in the fields of rocket technology, research, engineering, production, and testing—all presented in a very readable format, and amplified by long explanations whenever such explanations are necessary. An elaborate cross-referencing system allows the reader to pursue the explanation still further, if he so desires, while more than 450 photos and drawings, many never previously published in book form, supplement the written text. The appendix includes a bibliography and reference list, several hundred abbreviations and what they stand for, and a listing of standard rocket propulsion symbols.

Chief editor John W. Herrick of Space Technology Labs and associate editor Eric Burgess of Telecomputing Corp. have performed a valuable service in putting the encyclopedia together.

For this reason, it is unfortunate that the book is marred by a good many errors, as well as typos. After all the work that went into compiling an encyclopedia of this kind, it seems a shame to have its value cheapened by hastily rushing it into print without a careful check of the manuscript. One other point: While called a "rocket encyclopedia," it is actually much more of a propulsion encyclopedia, in view of the fact that it is this subject which receives by far the best coverage.

—**IH**

ASTRONAUTICS Data Sheet — *Propellants*

Compiled by Stanley Sarner

CHLORINE TRIFLUORIDE (ClF_3)

One of the prime choices among prepackaged rocket oxidizers for developmental engines is chlorine trifluoride. The oxidizer approaches elemental fluorine in performance, is hypergolic with most fuels, and has excellent physical properties.

Physical Properties

Chlorine trifluoride is a pale green liquid, which vaporizes to form a colorless gas, and freezes to a white solid. It has a somewhat sweet odor and is highly irritating even at low concentrations, similar to chlorine or mustard gas. It is extremely dense, has a low freezing point, and has a critical temperature high enough to allow liquefaction at ambient temperature at fairly low pressures. Table 1 gives some of the physical properties of the oxidizer.

Chemical Properties

With the exception of elemental fluorine, chlorine trifluoride is the most reactive chemical known. It reacts with every element except the rare gases, nitrogen, and possibly platinum and palladium. There is little doubt that it reacts under proper conditions with the vast majority of inorganic and organic compounds, inflaming those materials which do not build up a protective fluoride film, and converting oxides to fluorides. The oxidizer will attack soft glass and asbestos, and occasionally will ignite fluorocarbon polymers. It does not react with Pyrex glass. Table 2 gives some of the chemical properties of chlorine trifluoride.

Toxicity

Chlorine trifluoride is highly toxic (of the order of HF) and extremely irritating to the eyes, skin, and respiratory tract. By analogy, maximum allowable concentration in air for an eight-hour day of three parts per million by volume is suggested by one manufacturer. Concentrations of 50 ppm or more may be fatal in 30 min to 2 hr. In practice, however, fatal concentrations would be so irritating to the eyes and respiratory tract as to make the area intolerable. Protective clothing should be worn but not relied upon, since there is no known material completely suitable for protective fabrics.

Materials for Handling

Although ClF_3 attacks most materials, it can be handled in copper (to 400 C), brass, mild steel (to 250 C), monel or nickel (to 750 C), due to the formation of a protective fluoride film. Of these, monel or nickel, and 18–8 stainless steel are preferred. Highly fluorinated polymers, such as teflon, are resistant only to the vapor at ordinary temperatures.

Suitable gasket materials are soft copper, lead, and teflon impregnated with a high percentage (40%) of calcium fluoride. Valve packing may be abraded copper backed by teflon rings, or shaped packing of calcium fluoride-filled teflon. Pipe thread lubricant should be a water based graphite paste applied only to the male thread and omitted from the first two threads.

It is extremely important that all equipment in ClF_3 service be thoroughly cleaned to remove grease, scale, pipe dope, paint, or other contaminants. New equipment, such as valves, should be disassembled, degreased, and reassembled with proper packing before use.

Cost and Availability

Chlorine trifluoride is available from two main suppliers at prices of \$2.50–\$2.85 per pound in 10–20 ton per annum requirements, or at \$3.50 per pound in 150-pound net cylinders. It has been estimated that large-scale production could bring the cost down to \$.50 per pound.

Table 1. Physical Properties of ClF_3

Boiling Point	11.75 C	53.15 F
Freezing Point	−76.32 C	−105.4 F
Critical Temperature	153.5 C	308.3 F
Critical Pressure	32.3 atm	475 psia
Vapor Pressure	$\log P = 7.42 - \frac{1.292 \times 10^3}{T}$	
Density at 25 C (77 F)	1.81 gm/cm^3	113 lb/ft^3
Viscosity at 25 C (77 F)	0.42 centipoise	—
Trouton Constant	20.8	—
Molecular Weight	92.457	—

Table 2. Chemical Properties of ClF_3

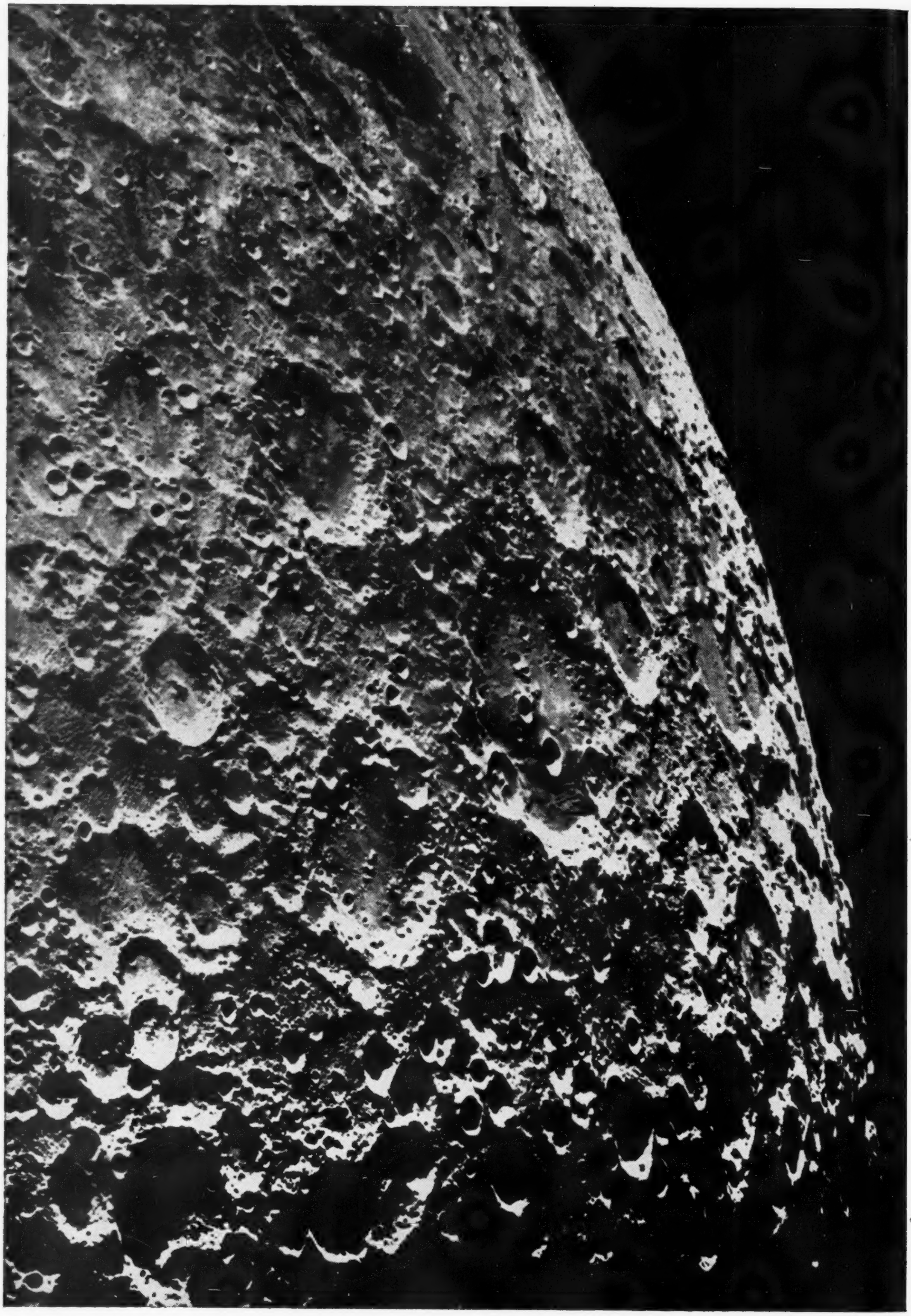
Heat of Formation (liquid) at 25 C	−42.94 kcal/mole
Heat of Vaporization at Boiling Point	5.74 kcal/mole
Heat of Fusion at Freezing Point	1.82 kcal/mole
Heat Capacity at 5 C (41 F)	28.02 cal/mole/C
Maximum Allowable Concentration (in air for 8-hr day)	3 parts per million

Table 3. Theoretical Performance of ClF_3*

Fuel	Specific Impulse (Sec) Frozen Flow	Specific Impulse (Sec) Equilibrium Flow	Chamber Temperature Deg K**
N_2H_4	279	294	3586
UDMH ($C_2N_2H_8$)	269	280	3383
RP-1	251	258	3111
Li	309	332	5200

* P_c = 1000 psia; P_e = 14.7 psia; optimum O/F ratio.

** Corresponds to equilibrium flow impulse.



Lab and Nonthrust Rockets

(CONTINUED FROM PAGE 30)

the high temperature and energy contents in the exhaust jet. Stripping paint films from a metal base, cutting and piercing nonferrous metals, glazing flame-sprayed ceramics to reduce surface porosity, and use as a heat source in the hot machining of metals are some of the applications that come readily to mind.

Another field of use is foreseeable for rocket engines based on the high momentum of the jet. In this area some obvious applications could be in providing a driving source for jet ejectors or high-intensity whistles. Perhaps a less obvious use might be in cleaning brush for emergency fire breaks; anyone who has witnessed the impact of a rocket exhaust against the earth can readily imagine its effect against brush. Still very much and unknown is the possibility of using rocket exhaust as an unshrouded ejector to influence local wind movements. At present, the rocket engine is the only known device which can liberate nondestructively and controllably sufficient energy to cause such effects on an appreciable scale. Other large sources of energy, such as nuclear or even chemical explosives, appear too hazardous to be considered. What applications, if any, that can be found for such a use remain for the future.

Another aspect of rocket engines that can inspire applications is the enormous energy release possible in a limited volume; nearly the total of experience and technology relating to high-intensity combustion devices is derived from the field of rocketry. At the present time, the use of such combustors outside of rocket engines themselves is as gas generators driving turbines which in turn provide auxiliary power for missiles. Future applications, outside of the missile field, can probably be expected.

In general, as the basic cost of labor increases, the "power assist" supplied per man also increases. Because rocket engines and rocket-type combustors represent compact sources of large power release, we can look forward to increased applications of these devices to nonthrust uses in the future. The expanding scope of rocket propulsion technology will continue to provide the basic knowledge and skills from which such new applications will be derived. Specific factors controlling progress will be those of economics and those relating to our ability to take advantage of available "knowhow" in new and ingenious ways to meet demands quite different from propulsion requirements.

◆◆

People in the news

APPOINTMENTS

Harry J. Goett, former chief of the Full-Scale and Flight Research Div., NASA Ames Research Center, has been appointed director of NASA's new Goddard Space Flight Center. **Emerson W. Conlon,** taking a leave of absence as director of research, Drexel Institute of Technology, has accepted appointment as NASA assistant director of aeronautical and space research (powerplants), succeeding **Addison Rothrock,** new scientist for propulsion in the agency's Office of Program Planning and Evaluation.

Jerome S. Goldhammer has taken a leave of absence as manager of reconnaissance systems and planning, Chicago Aerial Industries, to join ARPA.

Howard S. Wolko, formerly with Bell Aircraft's Space Flight Div., has joined the AF Office of Scientific Research Mechanics Div., where he will plan, formulate, initiate, and monitor the division's sponsored research in aerostructures.

General Osmond J. Ritland, Commander of AF Ballistic Missile Div., has been promoted to Major General.

Angelo Miele, former professor of aeronautical engineering at Purdue Univ., has been named director of Astrodynamics and Flight Mechanics at Boeing's Scientific Research Labs in Seattle. **Arthur Lusty, Robert Pritchard,** and **David Hull,** former students of Dr. Miele, will work with him. **George S. Schairer,** director of research, has been elected vice-president of research and development.

Morris Feigen has been named manager of the Engineering Design Dept., Space Technology Labs, and **Philip N. Anderson** assistant manager. **Lloyd G. Ludwig** has been appointed staff assistant to the director of the Vehicle Development Lab. Within the Telecommunications Lab, **R. G. Stephenson** has been named senior staff engineer, R&D Div., and **Arnold Rosenbloom,** manager, Computer and Guidance Dept.

David A. Young, former chief of ARPA's space technology program, has been appointed director of the Corporate Long-Range Planning Div. at Aerojet-General. **Marvin H. Gold** has been upped from assistant manager to associate director of chemistry for the Chemical Div.

Capt. Robert F. Sellars (USN), former president of the ARS Florida Section, and Commanding Officer, Naval Ordnance Test Unit, and Director of Navy Tests, Atlantic Missile Range, is being transferred to duty as Commander, Submarine Squadron One in Pearl Harbor.

William G. Purdy, former director of plans and programs for Martin-Denver, has been named director, Saturn operations, and **Robert S. Williams,** former manager, systems tests, will serve as deputy director. **Robert G. Swope,** former manager of contract administration, becomes director of plans and programs for Titan. **Adolph Vlcek Jr.,** former research manager, Baltimore Div., has been appointed director of manufacturing.

Don J. Todd has been named chief of gas turbine projects for the Tapco Group of Thompson Ramo Wooldridge, Inc.; **Thomas A. Johnston** becomes chief of a new space power systems group in the Research and Engineering Requirements Dept.; and **John B. Crobaugh** and **William P. Bente** have been named manager of power and fuel systems works, respectively.

J. A. Gorgenson has been named manager of Douglas' air-launch ballistic missile (ALBM) weapon system office, while **J. C. Solvason** becomes chief project engineer, and **V. E. Crosley,** assistant weapon system manager. **H. E. Bauer** has been assigned to missile aspects of the ALBM program; **S. L. Gehring,** ground support equipment; and **C. E. Starns,** aircraft support. **W. H. Hess** and **L. E. Lundquist** have been named Thor systems project engineers in the Santa Monica Div. Missiles and Space Systems Engineering Dept. **Charles C. Goodrich** has been named Douglas representative at Redstone Arsenal. He previously was project engineer for the Nike series at White Sands.

David D. Coffin, formerly vice-president and manager of Raytheon's Missile Systems Div., has been elected group vice-president, government. **T. C. Wisenbaker,** former assistant manager, succeeds Coffin as division manager. **Homer R. Oldfield Jr.** becomes a vice-president, in addition to his position as manager of the Government Equipment Div. **E. Nevin Kather** has been promoted from assistant manager to manager of the Microwave and Power Tube Div. **George A. Strichman,** former manufacturing manager of GE's Small Aircraft Engine Dept., has been named to the new post of director of manufacturing services.

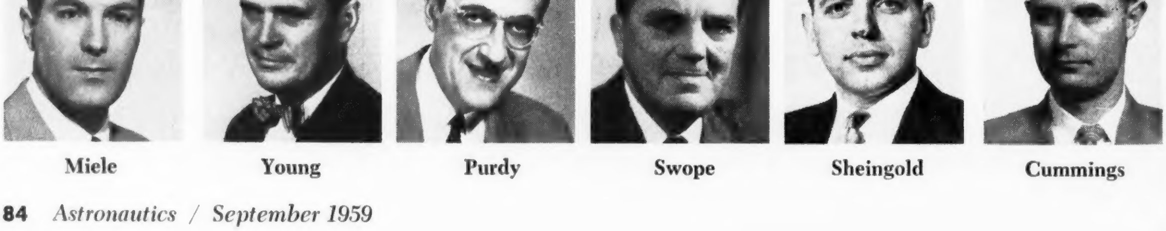
Edward G. Uhl, former vice-president of the Martin Co., and general manager of its Missile Div., has joined Ryan Aeronautical Co. as vice-president of technical administration.

Paul A. Libby has been appointed assistant director of the Aerodynamics Lab at Polytechnic Institute of Brooklyn. **Antonio Ferri** is director of the Freeport facility.

Roy J. Sandstrom, former vice-president of engineering, Bell Aircraft, has joined Bendix Aviation Corp. as assistant general manager of the Systems Div. **Tullio Tognola** has been named assistant director of engineering.

Leonard S. Sheingold, manager of the Applied Research Lab, Sylvania Electronic Systems, has been appointed to the AF Scientific Advisory Board.

Kimball C. Cummings, former associate director of research at Minneapolis-Honeywell's Aeronautical Div., has been named manager of engineering of the Beltsville, Md., Div.



Miele Young Purdy Swope Sheingold Cummings

Norman H. Mackworth, currently with Defense Research Medical Labs, Toronto, Canada, will join Dunlap and Associates in January, where he will be engaged in decision-making, vigilance, and man-in-space problems.

David A. Hill, former director of quality control, Hughes Aircraft, becomes manager of the Santa Barbara Research Center; **Alexander F. Brewer,** former head of the missile electronics section, technical director of the Products Group; and **G. Norris Shaw,** Washington representative for Hughes Tool Co.'s Aircraft Div.

John H. Buck has been appointed vice-president and general manager of two operating units of the Budd Co. He will assume managerial responsibility for Budd's Tatnall Measuring Systems Co. and Nuclear Systems Div.

DEATHS

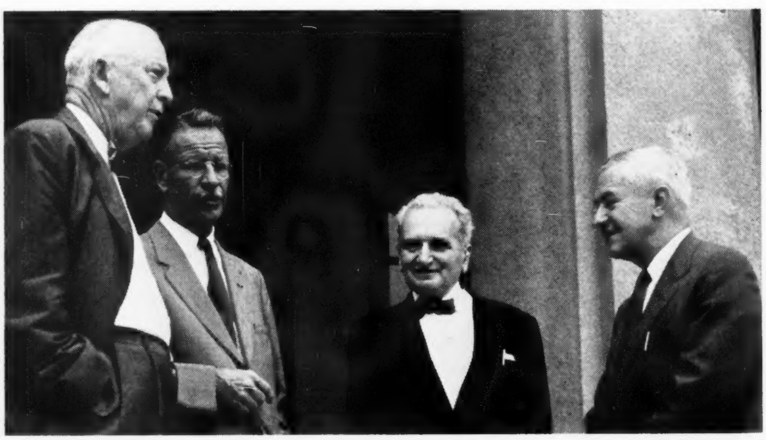
Erwin Loewy, founder and head of Loewy-Hydropress and vice-president of its parent company, Baldwin-Lima-Hamilton Corp., died in mid-July in New York. Mr. Loewy played an instrumental role in initiation of the AF heavy press program following WW II, and built some 60 per cent of the large presses constructed under the program. Several years ago, the company entered the field of missile and rocket handling and launching equipment, building the Polaris ship motion simulator, IGY satellite launching installations, and shipboard handling and launching systems. Mr. Loewy was awarded an AF scroll of appreciation last year.

Russell H. Varian, co-inventor of the Klystron tube and chairman of the board of Varian Associates, died unexpectedly of a heart attack in late July while on a vacation cruise in Alaska. He was 61.

After receiving his A.B. in physics and M.A. from Stanford, Dr. Varian worked and studied in the electronics field. In 1936, he and his brother Sigurd began an intensive effort to develop some device capable of operating at microwave frequencies. The result, announced in 1939, was the Klystron, invented and developed at Stanford with the collaboration of David Webster and the late William W. Hansen. During WW II, Dr. Varian was with Sperry Gyroscope, which sponsored continued development of the Klystron and related equipment. In 1948, he and his brother, with four associates, formed Varian Associates.

In recent years, and particularly since his election as board chairman in 1957, he had been free to devote time to scientific pursuits. One result of his work is the Vanguard instrument which will be used to measure magnetic fields in space. In addition to the Klystron, Dr. Varian had patents issued or pending on more than 100 other devices in the fields of thermionic tubes, radar, missiles, and nuclear magnetic resonance.

Aerojet to Finance Von Karman Lab



Theodore von Karman (third from left), rocket pioneer and aerodynamicist, discusses plans for new Karman Laboratory at CalTech with (left to right) Dan A. Kimball, president of Aerojet-General whose $400,000 gift will finance the lab; L. A. DuBridge, president of CalTech; and Dr. Clark Millikan, director of CalTech's Guggenheim Aeronautical Lab, which Dr. von Karman formerly directed. New Karman Lab will specialize in jet propulsion research, fluid mechanics, and hydrodynamics.

Commercial Spaceflight

(CONTINUED FROM PAGE 33)

and lunar landing vehicles.

The ships of Columbus and Cabot were useful for early exploratory trips but were not efficient commercially. Improved propulsion systems and greatly increased size were needed to make long trips commercially attractive.

Modern ships may weigh as much as 80,000 tons (the Queen Mary) or 90,000 tons (the U.S.S. Forrestal). These ships may be as much as 1000 ft long and 120 ft wide. In view of present technological capabilities, it is not unreasonable to expect that the evolution of the spaceship from the 1000- to the 50,000-ton class will take place much more rapidly than did the evolution of the surface ship.

To picture more clearly what an economical spaceship of the 1970's or 1980's might be like, let's assume that a single-stage vehicle is constructed weighing 50,000 tons, that is, comparable in size to present large surface ships. Such a spaceship would carry cargo and passengers to colonies on the moon on a commercial or partially subsidized basis (similar to some present transportation systems). Only the one-way trip will be analyzed in detail. The return trip would carry different cargo and would be much cheaper. Profits on the return trip might make up for some losses incurred on the much more difficult earth-to-moon trip.

We will assume, very conservatively, that the 50,000-ton moon ship will cost $5 billion to develop and build (compared to $1 billion for a modern aircraft carrier of the same size) and that such ships will make an average of 100 trips. This comes to $50 million per trip. If we assume a round figure of $100 million for the total cost of a trip, we have a $50 million allowance for propellants, crew wages, etc.

The total velocity change required for a vehicle to leave the earth, fly to the moon, and land can be put conservatively at 45,000 fps. The payload that a single-stage rocket can propel through this change in velocity will vary with the rocket's structural efficiency and propellant energy (specific impulse).

Structural efficiency may be expressed by the propellant fraction (λ), which is the weight of propellant divided by the vehicle gross weight minus the payload. A value of 0.75 has been assumed for λ in our conceptual design of an economical spaceship. This value, low for a single-stage rocket, was chosen to allow for the weight of wings to permit landing on earth on the return trip.

The atmospheric and gravity loss factor (K) is given a value of 0.93. This is higher than typical values for one-stage, short-range rockets or first-stage rockets, because the high-performance moon rocket will operate directly against drag and strong gravity fields for only a small part of its powered flight.

The graph on page 33 illustrates the effect of specific impulse on cost for the 50,000-ton moon ship. Notice that a reasonable goal for specific impulse lies between 1400 and 2000 sec. Below 1400 sec, costs mount very rapidly. Above 2000 sec, further increases in specific impulse bring only small reductions in cost.

The increase in cost for developing propulsion systems of higher specific impulse has not been included in the cost per payload-pound in this graph. The cost per payload-pound changes rapidly because of change in the ratio of gross weight to payload resulting from improvement in specific impulse. No other changes are considered.

On the other hand, we assume that there will be some direct relationship between performance of a propulsion system (specific impulse) and difficulty in development. If a 3000-sec system can be developed just as easily as a 2000-sec system, the former is obviously preferable, however small the decrease in transportation cost.

Highest Cost is $6000

If the moon ship is used to carry passengers and the weight allowance per passenger is 300 lb, then the highest cost shown in the graph results in a one-way fare of $6000. This comes to $0.025 per mile—lower than present air passenger rates!

Under high-altitude or vacuum conditions, values for specific impulse of standard chemical propellants are in the neighborhood of 300 sec. High-energy propellant combinations using fluorine, ozone, or hydrogen, may go as high as 450 sec. The first nuclear rockets may have specific impulse values as high as 800 sec. Some estimates of advanced nuclear rockets, using the reactor-plus-working-fluid approach, achieve values as high as 1000 to 1200 sec.

But the graph on page 33 indicates the economical spaceship cannot be designed for the use of chemical propellants or even early nuclear rockets. There is some possibility that the reactor-plus-working-fluid nuclear rocket may eventually approach the lower limit of economical operation, particularly if staging is used, but optimum moon ship design will require some other method of propulsion.

Some very high-performance pro-

pulsion systems that have been considered are the free radical system, the gaseous core fission system, the fusion reaction system, and ion and plasma systems. Of these, the first three would theoretically satisfy requirements for the moon ship and may eventually be used. Unfortunately, we don't know enough now to start development of these or other theoretical high-performance systems. Development could start on ion or plasma systems now, but times of travel to the moon are too long for these low thrust systems. However, they might prove to be economical for hauling freight, where time is not as important as it is for passenger service.

In spite of the limitations of the systems considered, we should not be discouraged in our quest for an economical spaceship. The potential performance for nuclear rockets is so high, and the reward for releasing this potential is so great, that we can be confident methods will be found for economical application of nuclear energy to spaceflight.

A nuclear pulse rocket under study by the Martin Co. for several years can serve to illustrate the enormous potential of nuclear-energy propulsion systems for spaceflight. Of course, we can only speculate as yet about the practical problems of constructing such a vehicle. But as shown on page 33, it is within the bounds of engineering science.

In the chemical rocket engine, heat energy is liberated and transformed into the kinetic energy of the exhaust gases in the center of the combustion chamber and not adjacent to any solid materials. In the nuclear reactor system, on the other hand, the heat generated in the reactor must be transferred through solid walls to a working fluid. Because of this restriction, the nuclear engine would be no better than, and probably not as good as, the chemical engine if it were not for its ability to use working fluids of low molecular weight. The nuclear engine can use pure hydrogen as an expellant, whereas the chemical engine must use an oxidizer plus fuel.

Unfortunately, there are no oxidizers with very low molecular weight. A liquid chemical engine of current design has a combustion temperature close to 10,000 F and transpiration-cooled walls at less than 2000 F. If this engine could operate with pure hydrogen without the need for a high-molecular-weight oxidizer, it would have a specific impulse of about 1500 sec.

The obvious solution to the severe temperature limitation of the nuclear rocket is to design an engine that is more like the present chemical rocket

engine, with the nuclear reaction and transfer of heat to expellant gases taking place in the center of a thrust chamber. This is the basic principle of some of the proposed fusion propulsion systems. We apparently do not know enough about sustained fusion, however, to start development of such a rocket.

One efficient high-temperature method of releasing nuclear energy which we do understand, and have been using for 14 years, is the nuclear bomb. It is the somewhat surprising conclusion of a study started at Martin in 1956 that there is no fundamental reason why nuclear bombs cannot be used for rocket propulsion.

The usual reaction to this statement is that the energy release of a nuclear bomb is far too large to power any conceivable rocket engine. This somewhat emotional reaction ignores the facts that nuclear bombs can now be made much smaller than the earliest models and that rockets can be made much larger than any used to date.

A nuclear bomb can be designed to have such low efficiency that only a small fraction of its potential is realized. Bombs can be made that explode with an energy of perhaps only 0.01 kiloton (KT), compared to the Hiroshima bomb of 20 KT.

Might Be Made Cheaply

Perhaps we should refer to "energy capsules" or very fast expendable reactors rather than bombs. The "bomb" designed for propulsion would undoubtedly differ from bombs designed for destruction. It is quite possible that the propulsion capsule could be made more cheaply than present weapons.

In any event, a 0.01-KT explosion could be contained easily and safely in a steel thrust chamber weighing 100 tons with a radius of about 26 ft. The maximum pressure at the wall of the chamber should be no higher than 1000 psi—comparable to that of some existing rockets.

Using such a thrust chamber in a spaceship of reasonable efficiency would require a gross weight on the order of 500 tons—no larger than some vehicles already in the early phases of development.

While a rocket of this type could be constructed, and might be very useful for military or scientific purposes, it would not be the economical space vehicle we are seeking. The cost of the energy capsules is much too high to operate such a vehicle on a paying basis. To make the nuclear pulse rocket operate at a profit, it should be increased to about 50,000 tons.

The great advantage of this large size should be clear from considera-

tion of the economics of nuclear bombs. A 0.01-KT bomb would cost as much to produce as a 1-KT device. Thus the propellants for the 500-ton rocket would cost as much as those for a 50,000-ton rocket. Propellant cost of the large rocket, with 100 times more payload, is no higher.

In the large nuclear pulse rocket, 1.0-KT energy capsules would be fired at a rate of about 1 per sec from a low velocity gun and fused to detonate in the center of a 240-ft-diam steel thrust chamber weighing some 10,000 tons. Water would be pumped into the chamber through small openings in the walls at an average rate of 10,000 lb/sec to protect the walls from thermal radiation.

100,000-Ton Thrust Achieved

The thrust chamber would contain 270 tons of air at sea level. At the first explosion, this air and the cooling water would be expelled from the chamber at an average velocity of 12,000 fps. The resulting thrust would be 100,000 tons.

After the first explosion, air would enter through intakes in the front of the vehicle, as in the conventional jet engine. Flight through the atmosphere would be programed so that increasing altitude would be partially offset by increased speed to provide a large mass of air in the thrust chamber for each successive pulse. However, the air at high altitudes would eventually become too thin to provide thrust even at high speeds and larger amounts of water would be required. The water would be necessary not only for reaction mass but even more for cooling.

By the time the vehicle reached a velocity of about 15,000 fps, the air-intake phase of operation would have been replaced completely by pure rocket propulsion. The weight of water per pulse would have increased to 20 tons, as compared to 5 tons at sea level, and the exhaust velocity would have increased to 45,000 fps, representing a specific impulse of 1400 sec.

During operation in the atmosphere, 1000 pulses would be required to accelerate the vehicle from zero to 15,000 fps. During the pure rocket phase outside the atmosphere, 1600 pulses would be required to accelerate from 15,000 to 45,000 fps. Of course, this velocity change would not all occur at one time. The vehicle would acquire a maximum velocity of no more than 36,000 to 37,000 fps to reach the moon. The difference between these numbers and 45,000 fps would be the velocity change needed for landing on the moon and for

maneuvering.

The weight of the rocket, less the payload, is assumed to be 50,000 tons. The payload for a moon trip would be 23,000 tons, so the gross weight would be 73,000 tons.

At a cost of $100,000 per energy capsule, 2600 capsules would cost $260 million. This results in a propellant cost per payload-pound of $5.65. If the vehicle cost $5 billion and was used for 100 trips, depreciation cost per pound of payload would be $1.09. Thus, the major costs would add up to $6.74 per pound of payload.

It may be of interest to compare this figure with the cost of shipping freight by conventional means and production costs for some manufactured goods. If rail lines extended to the moon, the cost per pound of payload would be approximately $5. If aircraft could fly the distance, the cost would be more like $25 per pound.

These transportation costs would be far too high to consider transportation of many industrial chemicals, structural metals, raw materials, etc. On the other hand, precision instruments such as watches, complex electronic equipment, pharmaceuticals, dyes, perfumes, etc., cost $1000 or more per pound. Transportation costs for this kind of merchandise would be relatively small.

Costs for return flights from the moon would be considerably less than for the outward trip because a velocity change of less than 10,000 fps would be required. In fact, costs might be only one-tenth those for the earth-to-moon trip, or $0.67 per pound. Many metals and chemicals might thus be hauled economically.

Support for lunar colonies will come initially from the government for military and scientific purposes and later from the general public for vacation and health resorts. As has been pointed out, cities on the moon may prove to be the answer to the prayers of the feeble, paralytics, heart cases—all whose health, usefulness, and general well-being would benefit from a sixfold reduction in body weight.

But after the initial phases of lunar colonization, industries of all types will grow. At first, these industries will be in support of the spaceports, the military installations, the scientific laboratories, and the resorts. When transportation costs come down to the levels discussed, lunar industries of special types could actually compete for earth markets.

Thus, economical space propulsion systems of types that should be available by 1975 or 1980 will permit the spread of civilization across the new space frontier to the moon. ◆◆

Boston Univ. Schedules Course in Astronautics

Boston Univ. Evening Div. is introducing an accredited course entitled "Principles of Astronautics" in the fall semester. A two-semester course, meeting for three hours a week, it will be given by Gerald Ouellette of the MIT Instrumentation Laboratory, and active ARS New England Section member. The course will cover most of the basic problems associated with interplanetary flight and treatment will be of a theoretical nature.

The course is open to engineers and graduate and upper level undergraduate students. Details may be obtained by writing to the Physics Dept, at Boston Univ.

Map of the Moon

GE offers free a technically accurate map of the moon. Write Missile and Space Vehicle Dept., 3198 Chestnut St., Philadelphia 4, Pa.

Missile Market

(CONTINUED FROM PAGE 68)

of this year against \$1.23 in 1958, this column estimates earnings of \$4.50 to \$5.00 a share for full 1959, compared with \$4.01 last year. Moreover, sales could continue spiraling higher during the next few years while earnings might soar as an increasing percentage of Martin's programs shift from a cost-plus-fixed-fee basis to more profitable fixed price production contracts. Eventually, the stock market, recognizing the profound change in the company's product mix, will evaluate it as a leader in advanced electronics and appraise its earnings more liberally.

Listed on the New York Stock Exchange, Martin has 2,924,877 shares of stock outstanding, preceded by \$20 million of long-term debt. For the speculatively inclined, warrants permitting the purchase of Martin common at \$40 a share until November 1, 1963, and then at \$45 a share through November 1, 1968 are traded on the American Stock Exchange.

Missile Stock Studies

Recent reports on the following companies or industries in italics have been prepared by the investment or brokerage firms specified. Ordinarily, readers can obtain a copy of the study desired by writing to the firm.

Magnavox Co., A. M. Kidder & Co., N.Y.C.

Aeroquip Corp., White, Weld & Co., N.Y.C.

Square-D Co., Hirsch & Co., N.Y.C.

Garrett Corp., Fahnstock & Co., N.Y.C.

General Dynamics Corp., Hardy & Co., N.Y.C.

Beryllium Corp., Van Alstyne, Noel & Co., N.Y.C.

Electronics Industry Review, Bache & Co., N.Y.C.

Sanborn Co., Saunders, Stiver & Co., Cleveland, Ohio.

Data on Tetranitromethane

New data sheets on tetranitromethane are available from Hummel Chemical Co., 90 West St., New York 6, N.Y. Technical inquiries will also be answered.

Rocket Sled Hits Mach 2.66

A rocket sled powered by Thiokol's Recruit rockets recently hit Mach 2.66 on Edwards AFB's new 20,000-ft dual-rail track. The sled has been designed to prevent aerodynamic choking, that is, compression of air between sled body and ground tending to buck sled off track.

Nova—Manned Lunar Rocket

(CONTINUED FROM PAGE 23)

too ponderous unless we considered nuclear or electrical propulsion schemes. The same conclusion applies to the orbital rendezvous method.

This graph therefore presents the reasons for assuming re-entry at hyperbolic velocity. It also emphasizes the need for research and devolpment to provide this capability irrespective of direct or rendezvous approaches to a manned lunar mission.

Direct-Flight Lunar Vehicle

Let's take a look at a typical direct-flight lunar vehicle constructed along the lines of the foregoing design considerations. An outline drawing of such a vehicle, which also shows vehicle sizes and weights, appears on page 21.

The vehicle stands about 220 ft high and the first stage is some 44 ft in diam. The conical portion at the top contains the landing or fourth stage, the lunar takeoff or fifth stage, and the manned-capsule payload. Upon return to earth, the payload will weigh 8000 lb, including the crew, equipment, capsule, guidance and control, and parachute. Two or three men will constitute the crew.

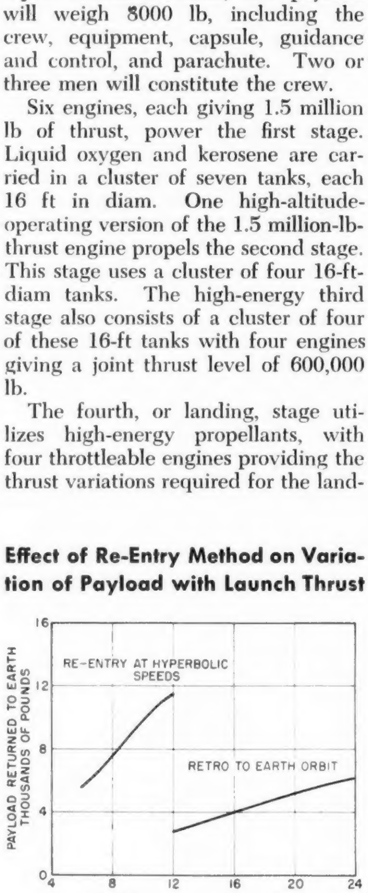
Six engines, each giving 1.5 million lb of thrust, power the first stage. Liquid oxygen and kerosene are carried in a cluster of seven tanks, each 16 ft in diam. One high-altitude-operating version of the 1.5 million-lb-thrust engine propels the second stage. This stage uses a cluster of four 16-ft-diam tanks. The high-energy third stage also consists of a cluster of four of these 16-ft tanks with four engines giving a joint thrust level of 600,000 lb.

The fourth, or landing, stage utilizes high-energy propellants, with four throttleable engines providing the thrust variations required for the landing maneuver. The landing stage must have the capability for hovering to allow final choice of a landing spot by the pilot. Approximately 1 min of maneuvering or hovering time is provided. Retracted landing legs appear on the side of the fourth stage. When extended for landing, the legs span a distance of 40 ft for purposes of stability.

The fifth stage is placed in a cylindrical tube that pierces the tankage of the landing stage. At takeoff from the moon, the fifth stage slides out of the landing vehicle on rollers. We choose this arrangement because it presents a vehicle with a low center of gravity which will reduce any tendency for the vehicle to topple on the surface of the moon. In addition, the propellant tanks of the spent landing stage which surround the fifth stage serve as meteor bumpers and shielding against thermal radiation. Furthermore, no landing loads are transmitted through the return stage, thus minimizing the danger of a rough landing.

The manned capsule is an enlarged version of the one used in Project Mercury. It is a truncated cone, with a maximum diameter of 12 ft and a height of 14 ft. Inside the capsule, two levels are provided. The lower level contains contoured couches for the crew, controls, communications, and a folding air-lock for use on the moon. The upper level contains food, power supply, exploration gear, and work space. The outer surface of the capsule is covered with ablative material for insulation against and removal of heat generated during atmospheric re-entry.

Effect of Re-Entry Method on Variation of Payload with Launch Thrust



Guidance Requirements

What about guidance? Guidance system requirements normally are divided into three phases: Initial, mid-course, and terminal. For this manned lunar mission, we must provide these three functions for both the moon-bound and earthbound trips. In addition, we should consider the pilot's capabilities in performing major guidance tasks or in monitoring an automatic system. At present, the latter is most reasonable, since we believe that an unmanned return vehicle—a spare, so to speak—should be placed on the moon before the manned flights to provide an escape route should the manned vehicle be damaged upon landing.

The initial guidance phase from launch to earth-escape can be accomplished with sufficient accuracy by inertial systems now under development. Mid-course guidance by means of earthbased radio can direct the vehicle to an accuracy of 50 mi for a

lunar impact trajectory. The terminal phase involves the final approach to the moon and the lunar landing. These maneuvers require vehicle-contained guidance. However, lunar-based radio beacons will assist. A combination radar-optical system will sense altitude and velocity components relative to the lunar surface.

In all but the initial guidance phase during launching, the pilot can effectively monitor and override the automatic system if necessary. During the mid-course phase, in particular, the pilot can make optical observations of the lunar disk for distance and path angle measurements. The pilot will also be very effective in the final phase of the landing on the moon.

Re-Entry Maneuver

Launching from the surface of the moon will be guided by an inertial system that is aligned and calibrated by the pilot on optical sightings of stars and earth. The proper re-entry corridor in the atmosphere is reached by a combination of optical sightings from the vehicle and earthbased radio signals. During re-entry, the lift of the capsule would be used to modify the trajectory such that the vehicle follows a prescribed deceleration program and lands within the recovery area. The first phase of the re-entry maneuver will utilize vehicle-contained guidance monitored from the earth. After the initial slowdown to orbital speeds, earthbased radar in the landing area will control the vehicle.

If the description at the beginning of this article appears fanciful, it is only because our thinking has not caught up with the engineering advances of the last few years. What has been presented here is based on a preliminary design study of the type conducted by many agencies to assess the feasibility of a vehicle design. All of the engines are either being developed or are programed for development within the next few years. No new or exotic fuels are required. Indeed, our calculations reflect the sober degree of conservatism that should characterize a preliminary study. We believe feasibility has been shown.

There remains now the intriguing task of doing the job. ◆◆

Space Research for AOMC

Both ARPA and NASA have assigned million-dollar programs in space research to the Army Ordnance Missile Command, about a third of the funding going toward advanced propulsion devices.

Nose-Cone Liner

(CONTINUED FROM PAGE 39)

favorable price differential for castings requires that no major design changes be made during the production run. This factor was dominant in the selection of built-up construction for the third section. A number of system components (black boxes) were to be mounted in this section. Their sizes and number could not be finalized before the "freeze" date for liner structure design. Since changes in a cast structure pattern would be both expensive and time consuming, advantage was taken of the greater flexibility of fabricated-construction methods.

To minimize insulating shield thickness and weight, the nose-cone liner is designed to operate at 200 F. Moreover, the process for applying the shield subjects the liner to temperatures above 250 F for a period of several days. For these reasons, it is essential that the material for the cast sections of the liner be dimensionally stable at high temperatures.

The need for early delivery precluded the use of any but readily available magnesium casting alloys. Moreover, the high-temperature stability requirement just mentioned in-

dicated that a T5 temper (artificially aged only) would be necessary, since both the T4 (solution heat-treated only) and the T6 (solution heat-treated and artificially aged) tempers, although of greater strength, are subject to distortion at elevated temperatures. Cast magnesium in the T5 condition does not exhibit this disadvantage.

Magnesium alloy AZ91C is used commonly in the aircraft industry, but only in the T4 or T6 temper. No casting manufacturer would guarantee properties for this alloy in the T5 condition, so AZ63A-T5 was specified instead. Although the casting characteristics of this alloy are inferior to those of AZ91C, AZ63A is available in T5 temper.

Alloy AZ63A is subject to considerable micro-shrinkage, causing defects that are actual voids between the metal grains. While such defects weaken the structure, they are predominantly subsurface in nature, and would not be sources of stress concentration under bending or buckling loads. It is important, however, that the liner walls not be machined, since this would bring micro-shrinkage to the surface. This presented a problem. The forward and middle sections of the liner are large, thin-wall structures, having diameters and lengths approximately 250 times the wall thickness, which is 0.150 in. While the sand casting of this large a structure is an accepted practice in the industry, casting one with such extensive thin wall sections is not. Of the magnesium foundries approached, only one—R. H. Osbrink Mfg. Co. of Los Angeles—was willing to undertake casting the liner structure without machining the walls. The successful accomplishment of this task is a tribute to the unusual techniques employed by that foundry.

The forward section of the liner consists of a dome and a frustum, with the mid-section a continuation of the frustum. These sections were designed to fail either (1) by bending in the forward section at the tangency of dome and frustum, or (2) by buckling in a 19-in.-long bay in the mid-section. To demonstrate this, the two sections were bolted together and loaded under axial forces and external pressures. At 100 per cent design load, (1) the area of tangency reached yield stress and (2) the 19-in. bay buckled with classic circumferential waves, as shown on page 38. Magnesium alloys are considered to be brittle materials, yet the photo shows that the casting deformed appreciably before cracking.

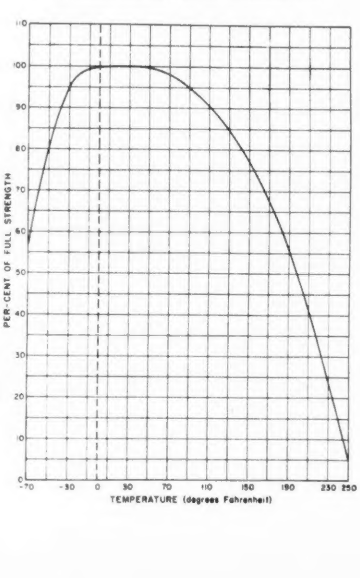
When a manufacturing organization is working to a tight schedule, the design engineer often is called on to provide a "quick fix." For example, a casting—such as those just discussed—may require a repair for a misrun caused by solidification of the molten metal before it completely fills the mold. Depending on its area, the resulting hole could be repaired by patching, welding, or riveting. In the case of the nose-cone liner sections, any such repair must provide a smooth exterior wall approximating a continuous surface.

The foundry that cast these liner sections devised an ingenious method of repair. The misrun is drilled out and tapped. An oversize, threaded plug is shrunk in dry ice, screwed into the hole, and allowed to expand at room temperature. To test such a repair, a 1-in. plug was inserted in the 19-in. bay of the mid-section, and the structure loaded. When the structure buckled, the plug did not deform and the threads did not strip. The plug merely pushed away from the casting. It is believed that, despite the plug, the lack of continuity of material in the area of the hole decreased local resistance to buckling. The center areas of long, unsupported bays should be uninterrupted, without repaired defects.

An R&D nose cone must have many sensors passing through liner and shield. Although these sensors are the nose-cone's reason for being, they require holes in the liner, and the weakening effect of these holes must be determined to assure optimum liner design. Tests showed that magnesium domes with holes which failed under compressive loads fractured at 75 per cent of the load required to cause failure of the undrilled domes. Distinct brittle fracture was apparent in these dome failures.

X-ray photos of test specimens cut from a liner mid-section showed that micro-shrinkage was very abundant in some of the specimens. After the X-rays were taken, the specimens were pulled in tension to demonstrate the correlation between micro-shrinkage and tensile strength. Results of these tests, shown in the chart on page 39, clearly reveal the weakening effect of micro-shrinkage. Specimens 4, 6, and 8 are the soundest and consistently have the highest strength (28,500 psi). Specimens 1, 2, 3, and 10 have the greatest amount of micro-shrinkage and the lowest strength (17,500 psi). Specimens 5, 7, and 8 are intermediate in internal quality and strength (23,000 psi). The photo on page 39 shows two mirco-sections of micro-shrinkage. The black areas are the intergranular voids.

Typical Strength of Adhesives



No Basis for Rejection

It should be noted that tests of this type can only indicate local strengths within the casting. They cannot provide a basis for casting acceptance or rejection.

The large differences in strength between sound and poor areas in the same casting demonstrate an important point in casting design and purchase. If the design drawing indicates areas of high stress, the foundry can arrange its pouring, cooling, and other operations so as to concentrate micro-shrinkage in low-stress areas and provide sounder metal in the high-stress regions. The cast part can then be designed to high strength values in critical areas, rather than to the low minimum values of Specification QQ-M-56. The high values must, of course, be specified to the foundry.

Successful production of a satisfactory liner from magnesium alloy AZ63A-T5 is being followed by investigation of the use of other, more suitable materials.

While the primary subject of this article is the liner, rather than the shield, fastening the two together is of vital concern in liner design. Hence, some of the problems involved will be discussed here.

Two methods were proposed for manufacturing the plastic-combination heat shield, both of which would employ a resin-impregnated filler tape wound on a male form. One method would use a mandrel as the male form; the other would use the liner itself. After wrapping, the plastic laminate and form would be enclosed in a rubber bag and cured under heat and pressure.

One advantage of the mandrel method arises from its ability to permit shields and liners to be made independently and simultaneously. This, however, would require that the shield be bonded to the liner, presenting

certain problems. The greatest of these results from the relatively large variations in the as-cast dimensions of the liner's exterior, including tolerances in diameter, concentricity, straightness, and out-of-roundness.

Interference Problems

Thus, no matter how accurate the dimensions of the mandrel, and hence the shield interior, there could be either considerable interference or clearance between shield and liner. Too much interference would prevent the shield from fitting the liner; too much clearance, in a poor adhesive bond. Since some plastics weigh more than magnesium, increasing the shield thickness to allow for liner tolerances would impose a weight penalty.

Wrapping the shield directly on the liner would eliminate the problem of shield-to-liner fit since each shield would be custom-tailored to its liner. However, other problems arise. In the curing operation, shield and liner are heated to high temperature and there may be a considerable differential of thermal expansion between the two dissimilar materials. Assuming that the plastic has a higher coefficient of expansion than the magnesium and aluminum of the liner, the following may occur:

1. The plastic may set and become rigid at the low temperature at the beginning of the cure, and as temperature increases, the shield will try to expand away from the liner. If the adhesive bond between the two is strong enough, compression is induced in the shield and tension induced in the liner. If the bond is not strong enough, shield and liner will separate. If the bond holds, the stresses will be relieved when the assembly returns to room temperature.

2. If the plastic does not become rigid until the upper temperature limit of the curing cycle is reached, the early expansion of the liner will induce no stresses in the liner or in the viscous plastic. As they cool to room temperature after curing, however, the newly solidified shield tries to contract more than the liner. After cooling, then, the shield is under tension while the liner is under compression.

3. Certain filler tapes, as manufactured, have residual tension stresses "built in." When cured on the liner, these residual stresses are relieved. The tape then attempts to contract and compress the liner. Any contraction of the shield during cure may collapse the thin walls of the liner or, if the liner is a dome or frustum shape that does not collapse, the contracting shield may push itself off the liner.

A constant search is underway for adhesives having the right strength, flexibility, ease of application and use-temperature range. The strength range of one plastic adhesive is shown in the graph on page 98.

Like all metals, the magnesium of the liner will lose some of its mechanical properties when it is heated, and not all the loss is recovered when it cools to room temperature. Test results and published data indicate, however, that magnesium and aluminum will suffer no significant property loss during the temperature cycle employed in curing the shield. Temperature cycling may, however, cause distortion of the liner, so any dimensions which must be held closely (such as body-fit bolt holes) should be machined after the nose-cone assembly has cooled to room temperature.

The magnesium and aluminum nose-cone design described in this article enabled GE's Missile and Space Vehicle Dept. to meet its commitment dates. Although the design of a particular nose-cone must be finalized by a given date, designing for an improved product is a continuous process. Our ambition now is to obsolete today's design. ◆◆

International scene

Program Set for 10th IAF Congress

The 10th International Astronautical Congress, to be held at Church House, Westminster, London, the first week in September, is shaping up as the biggest and best IAF meeting to date. Coming on the heels of the special British Commonwealth Spaceflight Symposium, which will provide a rundown on British astronautical progress and plans, the Congress is expected to attract an attendance of close to 1000.

The British Interplanetary Society, second largest member of IAF, is host society for the meeting. The preliminary program for the meeting follows:

SUNDAY, AUGUST 30

An informal reception will be held in the evening in the Banqueting Suite of St. Ermins Hotel, Caxton Street, Westminster, S.W.1, for all Congress participants and their guests.

MONDAY, AUGUST 31

Morning

The Congress will be opened by the Rt. Hon. Aubrey Jones, Minister of Supply, in a ceremony in Assembly Hall.

Afternoon

Double technical sessions and a business session in the Assembly Hall.

Evening

Official reception for all Congress participants given by H.M. Government at Lancaster House.

TUESDAY, SEPTEMBER 1

Technical sessions throughout the day, with business sessions in the Assembly Hall all day. A private excursion is being arranged for certain delegates in the evening.

WEDNESDAY, SEPTEMBER 2

The same procedure will apply, with an ARS cocktail party scheduled for the evening.

THURSDAY, SEPTEMBER 3

A day-long excursion is planned, with the evening free for participants to organize theater visits, etc. BIS will be host to a number of delegates in the evening.

FRIDAY, SEPTEMBER 4

Double technical sessions will be held during the day and a film night is planned if a sufficient number of films suitable for the program can be obtained. Business delegates will hold committee meetings during the day.

SATURDAY, SEPTEMBER 5

Morning

Double technical sessions will be held in Hoare Memorial Hall and the Convocation Hall and a business session will be held in Assembly Hall.

Evening

Concluding Dinner.

Papers accepted through July 20 are as follows:

"The Launching Parameters and Geometry of Orbits," by Fang-Toh Sun; "The Great Danger: Corpuscular Rays from the Sun," by C. E. Andersen; "Etude D'un Echangeur de Chaleur A Haute Temperature par Convection et Rayonnement pour un Autopropulseur Fissiothermique," by E. A. Brun and P. Berrier; "Limitation du Gain des Aeriens," by G. Gallede; "Mesure des Rendements de Combustion des Melanges Propergoliques," by L. Reingold; "Sur Deux Types des Propulseurs Electriques," by J. Ulan; "Les Limites de la Survie en Cabine Etanche au Cours des Voyages Interplanetaire," by F. F. Violette, M. Boiteau & S. Bernars; "Schwingungen von Raketen beim Eintauchen in die Atmosphere," by R. Merten; "On Directing Intensive Photon Beams," by E. Sanger; "Thermonuclear Research and Propulsion," by H. J. Kaeppeler; "Design Study of an Earth Satellite Evolving from a Four-Step Solid-Propellant Rocket Vehicle," by S. K. Kumar and B. R. Rav; "Observations on the Development of Space Crew Selection Procedures," by D. Flickinger; "Kepler's 3rd Law as a Particular Case of the Time Law of Omothetical Gravitational Trajectories," by G. Boffa; "Space Communications and Characteristics of Their Channels," by A. Boni; "On the Installation and Operation of a Permanent Base for Scientific Research on the Planet Mars," by G. Botti and P. Maimi; "On the Jet Orbital Lift for High Velocity Transport," by C. E. Cremona and D. Cunsola; "Compressible Boundary Layer of an Electrically Conducting Fluid," by L. G. Napolitano; and "On Some Functions of the Mass Ratio That Are Relevant for the Relativistic Velocity," by E. Ostinelli.

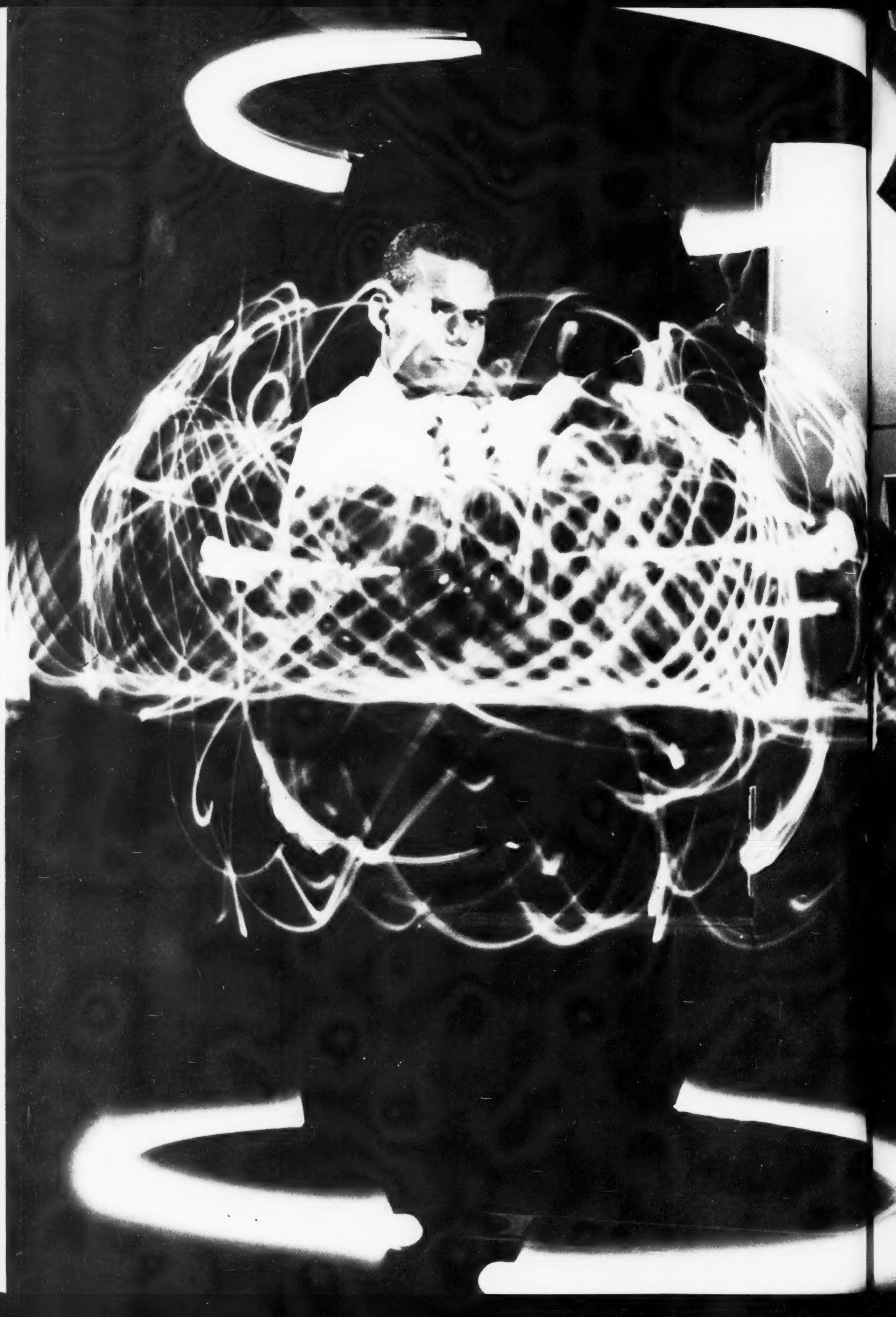
Also, "Postal Service by Automatic Rockets," by G. Partel, A. Angeloni, and P. Carusi; "Theory of the N-Step Relativistic Rocket," by M. Subotowicz; "On the Technical Realization of Weightlessness and Subgravity," by O. Wolczek; "Results of Experiments on the Biological Effects of Cosmic Radiation on Seeds of Hordeum (Gold Barley) Bonus 01515/B 19 (Gustafson) with Special Consideration of Heavy Primaries Effects," by Prof. J. Eugster and David Simmons; "A Practical Investigation of Spaceship Control Problems," by C. A. Cross; "Data From Satellite Orbits," by G. V. Groves; "Re-Entry Paths for Manned Satellites," by W. F. Hilton; "Accuracy Limits in Electronic Tracking of Space Vehicles," by P. F. von Handel and F. W. Hoehndorf; "Determination

of Air Density and Earth's Gravitational Field from the Orbits of Artificial Satellites," by D. G. King-Hele; "The Potentiality of Blue Streak in a British Spaceflight Program," by G. K. C. Pardoe; "Fuel Requirements for Interorbital Transfer of a Rocket," by R. N. A. Plummer; "Line-of-Sight Criteria for Interplanetary Navigation," T. Connors, A. Lawson, W. Huggett, and G. Rassweiler; "Lunar Exploration by Photography from a Space Vehicle," by M. E. Davies; "The Drag Brake Manned Satellite System," by R. W. Detra, A. R. Kantrowitz, F. R. Riddell, and P. H. Rose. "Ionospheric Scintillations of Satellite Signals," by H. P. Hutchinson and P. R. Arendt; "Application of Magnetohydrodynamics to Astronautics," by A. R. Kantrowitz; "Observation Satellites: Problems, Possibilities, and Prospects," by A. H. Katz; "Some Remarks on the Optimum Operation of a Nuclear Rocket," by G. Leitmann; "Magnetohydrodynamics and Its Application to Propulsion and Re-Entry," by R. X. Meyer; "On the Flight Path of a Hypervelocity Glider Boosted by Rockets," by A. Miele; "Tracking Objects within the Solar System Using Only Doppler Measurements," by R. R. Newton; and "Minimum Energy Requirements for Space Travel," by H. O. Ruppe.

Also, "Studies on the VIII Cranial Nerve of Biological Subjects During Weightlessness and Multiple G Loads," by G. J. D. Schock and F. R. Steggarda; "The Biological Satellite," by R. P. Haviland; "Secular Variation in the Inclination of the Orbit of an Earth Satellite (1957 Beta)," by Myron C. Smith and L. N. Rowell; "The Application of Solid Propellants to Spaceflight Vehicles," by H. L. Thackwell; "Predicting Man's Performance in Space Through Flight Simulators and Balloonborne Systems," by J. G. Vaeth; "Nuclear Rocket Missions and Associated Powerplants," by J. J. Newgard and M. Levoy; "Problems of Magnetic Propulsion of Plasma," by R. W. Waniek; "The Green Areas of Mars and Color Vision," by Ingeborg Schmidt; "The Weight Energy Concept of Man in Space," by H. G. Clamann; "Experiments in Space Cabin Simulators," by G. R. Steinhamp, W. R. Hawkins, and G. T. Hanty; "The Reaction of Terrestrial Microorganism to Simulated Martian Conditions," by I. Davis and J. D. Fulton; "The Human Eye in Space," by H. Strughold; "Biophysical Factors in a Human Lunar Ecosystem," by T. C. Helvey; "On the Corridor and Associated Trajectory Accuracy for Entry of Manned Spacecraft into Planetary Atmospheres," by Dean R. Chapman; "The Motion of an Orbiting Vehicle Subjected to Continuous Radial Thrust Including a Study of Planetary Encounters," by B. Paiewonsky; "Measurement of Jupiter Re-Entry Radiation," by David D. Woodbridge and Warren N. Arnquist; "Space Power," by William W. T. Crane; "Effects of a Meteoroid Impact on Steel and Aluminum in Space," by R. L. Bjork; "Multidirectional G-Protection during Experimental Sled Runs," by Harold J. von Beckh; "A Study of Hypersonic Ablation," by Sinclaire M. Scala; "Interplanetary Navigation," by Itiro Suira; and "Sur le danger Meteorique en Astronnautique," by N. Boneff.

Also, "Limitacao Dinamica da Liberdade do Espaco Cosurico"; "On the Apparent Motion of an Earth's Artificial Satellite," by J. J. de Orus; "Etude de la Fusée du Point De Vue Rélativité," by Vincent Rogla Altet; "Trajectories in the Earth-Moon System," by S. Goldblatt; "The Impact of Spaceflight on World Economy," by T. P. Bun; "Interplanetary Homing," by E. V. Stearns; "Nova, A Rocket for Manned Lunar Exploration," by Milton W. Rosen and Francis C. Schwenk; "Nonsteady Magnetic Boundary Layers in Hypersonic Flow," by P. S. Lykoudis and J. P. Schmitt; "Impulsive Midcourse Correction of an Interplanetary Transfer," by R. J. Gunkel, D. N. Lascody, and D. S. Merrilees; "Design Compromises in Space Power Systems," by Morris A. Zipkin and Erwin Schnetzer; "Differential Expressions for Low-Eccentricity Geocentric Orbits," by Samuel Herrick, Louis G. Walters, and C. Geoffrey Hilton; "Stability and Periodicity Problems on Satellites Rotating About Rotationally Symmetric and Unsymmetric Bodies," by Herbert Knothe; "The Sterilization of Space Vehicles to Prevent Extraterrestrial Biological Contamination," by R. W. Davies and M. Comuntzis; and "Recent Developments and Designs of the Ion Rocket Engine," by Robert H. Boden.

In addition, from four to six Russian papers will be presented at the meeting.



CAREER REPORT / The outlook for professional engineers in Florida

Three out of four engineering managers at Martin Orlando are electronic engineers

Take another look at that headline. It holds important career clues for electronic engineers on the way up.

Electronics is adding a new dimension at Martin Orlando. Engineers and scientists are designing, developing, and producing electronic systems for five major projects and several advanced research programs.

New programs of an advanced nature indicate Martin Orlando's progress and emphasis in electronics. Investigations are being conducted in communications, solid state devices, sensory apparatus, space mechanics, data processing, guidance and control systems, surveillance devices, and research.

Martin Orlando's direction in electronics is also revealed by the caliber of men in its programs. Three out of four engineering managers, and the chief engineer, are electronic engineers. The average age of these men is only 39 years. Martin Orlando's dynamic growth offers engineers unusual ground-floor opportunities for faster professional advancement.

In the stimulating atmosphere of a new 20-million dollar company-owned plant, electronic engineers are utilizing sixteen modern laboratories and complete technical facilities.

Engineers and scientists are needed now to manage and staff Martin Orlando's ambitious new electronic programs. If you are looking for the chance to move ahead professionally, please send us a brief description of your experience today.

MARTIN
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This engineer is testing advanced design components on a three-axis flight simulator in Martin Orlando's new 20-million dollar electronics and weapon system facility which is company-owned.

Mr. John F. Wallace, Director of Employment
The Martin Company, Orlando 1, Florida

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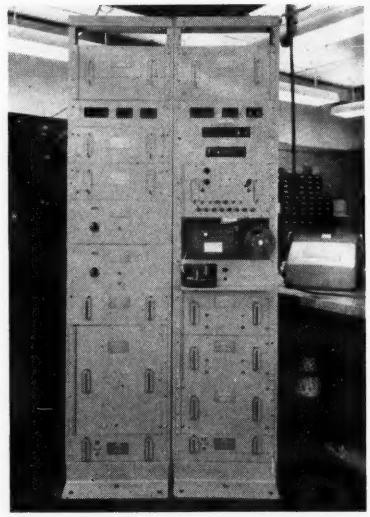
New equipment and processes

Acceleration Recorders: Of two self-contained recorders, the Multiple Recording Accelerometer Model MRA-440 (miniature reed gauge) and the Triaxial Recording Accelerometer Model TRA-200, the first directly senses and records data on the acceleration-time history of the motion along each of several mutually perpendicular axes, and the second records data on the response (shock) spectrum of the motion. They weigh 3 and 6 oz, operate between −50 and 160 F and −50 and 300 F, respectively. Leach Corp., Compton, Calif.

Helium-Recovery Balloons: Balloons of copolymer plastic material have been in operation, with constant flexing and exposed during the day to the sun's rays, for three years without showing signs of crazing. Loss from a 12,500 cu ft capacity balloon is estimated to be as low a 1 cu ft per 24 hr. Flexiliner Co., Pasadena, Calif.

Orbit Tracker: Datex orbit tracker system automatically follows the orbits of the sun, moon, and "radio" stars. Tracking data is programed on punched paper tape. Using digital



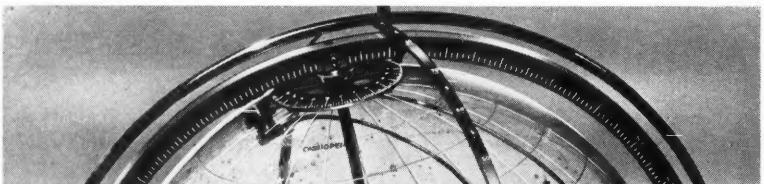
techniques and shaft position encoders, azimuth and elevation are obtained so that the antenna follows the motion of the selected celestial body. Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

Gas Control Console: As ground support equipment for use during checkout and launching of an ICBM, Model 13581 high-pressure-gas control console accepts inert gas from four external inlet pressure sources up to 8000 psig, and provides 12 outlets regulated from 3 to 5500 psig. The unit comprises four sections or subsystems which can be operated independently or simultaneously, and is ready for operation after connection to gas supply and outlet lines. Haskel Engineering and Supply Co., 1236 S. Central Ave., Glendale 4, Calif.

High-Speed Spectrograph: Optical speed of *f*6.3 and good dispersion, resolution, and spectral coverage are features offered by a new plane grating spectrograph. Designed for research where the light source is weak, or of normal brilliance but fleeting, the spectrograph may be used with high-speed drum cameras to extend response to short duration events. Jerrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.

Rotary Accelerator: Unit T-16-A has an acceleration range of 0 to 100 g at 5.5 in. nominal radius. Limiting size of test objects is a cube 60 in. on an edge; weights up to 500 lb at each end of the rotating arm can be tested. The unit has a 30-hp DC motor and a motor generator which operates from a 220- or 440-v, 60-cycle source. Schaevits Machine Works, Pennsauken, N.J.

Celestial Globe



A 14-in. celestial globe, designed by two staff astronomers of the Tokyo Astronomical Observatory, is now being offered by Lafayette Radio. Consisting of a colored terrestrial globe within a transparent celestial globe, it provides a working model of the universe, aiding in identifying stars and constellations, their relationships to each other, earth, and to times and dates.

All systems of spherical coordinates, such as the equatorial, galactic, ecliptic, etc., rotate with the sphere. Sun and moon are positioned by external controls, while artificial satellites can be made to travel around the earth automatically. Some 80 constellations, including all stars of first to fourth magnitude, are permanently molded on the sphere, along with horizon ring, time ring, fixed meridian ring, swinging meridian ring, sun and moon pointers, fixed ecliptic and detachable "planet."

Lafayette Radio Corp., 165-08 Liberty Ave., Jamaica 33, N.Y.

Wrapped-Wire Rocket Cases

Bendix Products Div. of Bendix Aviation, South Bend, Ind., is now producing wrapped-wire rocket cases, which have good strength-to-weight ratio. The wire is first processed into tape with an epoxy-resin binder, and then wound by special Bendix machines on a shaped mandrel. The wrap pattern is precalculated to produce uniform stress in the wires. Tested cases show the equivalent of 355,000-psi hoop strength.

Wrapped-wire cases can be formed in various shapes, such as these two.

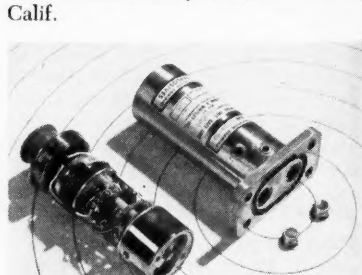
Mica Tubes: Tube and coil forms of inorganic-bonded muscovite mica paper remain physically stable and without loss of insulation value at 1100 F in diameters from $^1/_8$ to 6 in. and wall thicknesses from 0.004 to 0.060 in. Resinite Corp., Div. of Precision Paper Tube Co., 2035 W. Charleston St., Chicago 44, Ill.

Pressure Transducer: Model 717 transducer employs a Bourdon tube movement to assure accurate operation to 35 g at 2000 cps vibration. Weight, 14 oz; operating temperatures, −65 to 200 F; pressure ranges, 0–400 to 0–5000 psia; resistances, 1 k to 10 k ohms; power rating, 1.5 w at 165 F; resolution, as low as 0.17 per cent; static band, ±0.9 per cent. Bourns Laboratories, Inc., P.O. Box 2112, Riverside, Calif.

Differential DC Amplifier: Model 114A, for eliminating ground-loop noise, demonstrates a common-mode rejection of 180 db, DC, and over 130 db in the case of 60 cycle AC noise with up to 1000 ohms input unbalance. The input portion is isolated from the amplifier chassis; it "floats" with the transducer circuit. Choppers and demodulators are driven by an 880-cycle oscillator signal reduced to 440 pps. KinTel Div., Cohu Electronics, Inc., Box 623, San Diego 12, Calif.

Infrared Radiation Source: Model RS-8A, an addition to the OptiTherm line of infrared radiation reference sources, emits black body radiation over the temperature range of 500–1000 C. A conical cavity of high emissivity simulates the black body, and a power-proportioning electronic servo system provides the temperature control. Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn.

Explosive Initiator: Based on the action of an indexing rotary solenoid, the Model 2152A explosive initiator is designed to the requirements of military safety and arming devices. The solenoid controls the position of an out-of-line disk rotor between the initiating element and the final igniting charge. Loaded weight, 1 lb. Beckman & Whitley, Inc., San Carlos, Calif.



Noise Survey Meter: A palm-sized meter to monitor and measure noise hazards weighs only 12 oz, runs off a mercury battery, and adjusts to an "on-scale" reading by a thumbwheel attenuator. Sound pressure levels can be read in the range of 75 to 140 db. Mine Safety Appliances Co., Pittsburgh, Pa.

Pipette Controller: Bulb-free and valve-free, the Clinac Pipetter eliminates the need for mouth pipetting of bacteria, toxic liquids, corrosive, and radioactive material. A fraction of a drop can be delivered with accuracy greater than 0.01 ml. It is constructed of chromeplated metal and acid-resistant gum rubber. Tenso-Lab, Inc., Irvington-on-Hudson, N.Y.

Adjustable Speed Drive: Speed ranges of 100:1 and regulation percentages of 1 or 2 per cent are attained without tachometer feedback in a new line of speed drives in the $^1/_6$ to 10 hp range. The drives employ a magnetic amplifier driving thyratons in a full-wave circuit, followed by a DC shunt motor. Cleveland Machine Controls, 1155 Brookpark Rd., Cleveland 9, Ohio.

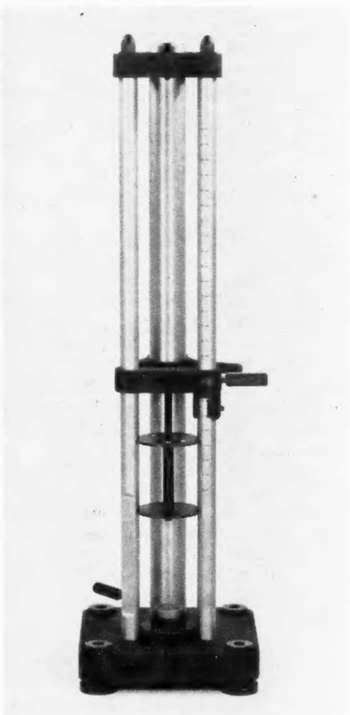
Heat Dissipating Coil: Servos and synchros can be operated at temperatures higher than their rated limits by means of an aluminum heat-dissipating coil clamped around the housing of the component. Internal heat generated by continuous operation is conducted to the coil fins. Manufactured to fit all standard size 8 to 15 components. Kearfott Co., Inc., Little Falls, N.J.

Flexible Noise-Damping Connectors: Series R Flex-Hose has an acoustical impedance 550 times less than that of steel pipe. Depending upon hose length, the pipe sections will attenuate up to 90 per cent of vibration and noise. The hose isolates pipe lines from the vibration of compressors, condensing units, and other equipment, handling pressures up to 250 psi. The Korfund Co., Inc., 32nd Pl., Long Island City 1, N.Y.

Ultrasonic Flaw Detector: Sonoray Model 5 uses the pulse-echo detection principle for both flaw detection and thickness measurement. Pulses sent intermittently into the material under test are displayed on a cathode ray tube. The bright oscilloscope trace is visible under normal shop lighting conditions. Its broadband amplifier permits a continuous range of test frequencies. Branson Instruments, Inc., 40 Brown House Rd., Stamford, Conn.

Electronic Flash: Stop-action photographs of objects and gas streams in motion at hypersonic speeds up to 1.5 mps may be made by use of the Micro-Sec electronic flash. The brilliant microsecond duration flash is the optical equivalent of electronic shutters having a millionth of a second exposure. Several models are available. Benedict-Sales Co., Bath, Pa.

Impact Tester for Liquid Propellants



This drop-weight tester, developed by Olin Mathieson in cooperation with the government, has been accepted as a recommended test by the Janaf panel on liquid-propellant test methods as one means of standardized propellant testing. It can be adapted for testing solids, slurries, and low-boiling-point liquids. Technoproducts Inc., P.O. Box 5293, Hamden 18, Conn.

Government contract awards

Avco Gets $73 Million Job For Titan Nose Cone R&D

The Air Force has awarded Avco Corp. a $73,360,000 contract for research and development of an advanced nose cone for the Titan ICBM that would have "a different aerodynamic shape" and "permit faster atmospheric re-entry to nullify missile defenses" of the enemy. Avco, prime developer of Titan nose cones, has been working on the project under an informal letter contract.

The Lycoming Div. has received an aggregate in AF-Army contracts of $13 million for flight-test and overhaul of T53-L-3 turboprop engines and development of a 960 shp version of the T-53 helicopter engine, currently rated at 860 shp. Lycoming recently received over $24 million in contracts for production of the T-53 engine. Also, Lycoming is making combustion chambers for Minuteman under a $6 million contract to Aerojet-General.

Navy Awards Thiokol $3.5 Million Contract

A $3.5 million Navy contract for production of Guardian II prepackaged liquid rocket engines has been awarded to Thiokol's Reaction Motors Div. Thiokol has completed delivery of Guardian I engines, the first prepackaged liquid powerplants to be considered by the services.

Honeywell to Develop Project Centaur Guidance

Minneapolis-Honeywell Regulator Co. has received a $5.4 million contract to develop and produce inertial guidance systems for Project Centaur. The contract was awarded by Convair-Astronautics, prime contractor on Centaur for NASA.

Clevite Studying Missile Materials

Clevite's Mechanical Research Div. has received a 12-month Navy BuOrd contract for investigation of high-temperature materials for missiles, e.g., modification of the properties of metals such as tungsten in fabrication. Cermets and fiber-reinforced composites will also be studied.

Operational Atlas Computer

Burroughs Corp. has delivered an operational Atlas guidance computer, and has received $9 million in new AF contracts, bringing its total as an AF prime contractor in the Atlas program to over $77 million. One man will sit at the console of the operational computer, which is based on solid-state devices and advanced circuitry.

Minuteman Digital Telemetering

Radiation, Inc.'s Florida Div. has received a multimillion-dollar contract from Boeing for an advanced digital telemetering system to be used in its Minuteman program.

Ascop Statistical Telemetering For Project Mercury

The Applied Science Corp. of Princeton will produce its dual-channel spectrum analyzer (one channel vibration, the other acoustical data) for Project Mercury use under a $100,000 contract to McDonnell Aircraft.

Melpar to Produce Talos Target-Detectors

Melpar, a subsidiary of Westinghouse Air Brake, will produce target-detecting devices for the Talos missile under three Navy contracts totaling $1.5 million.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formally advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army, and Navy contracting office:

AIR FORCE

AF Cambridge Research Center, ARDC, USAF, Laurence G. Hanscom Field, Bedford, Mass.

Cajun rockets, $51,948, Elkton Div., **Thiokol Chemical,** Elkton, Md.

Research directed toward the use of satellite radiation observations in numerical weather prediction techniques, $68,326, **Stanford Research Institute,** Menlo Park, Calif.

Rocket instrumentation engineering services, $34,531, **New Mexico College of Agriculture and Mechanic Arts State College,** N. M.

Radiation measurements from major missiles, $88,823, **Barnes Engineering Co.,** 30 Commerce Rd., Stamford, Conn.

Design, assembly, and operation of a prototype radiometric space vehicle tracking station, $30,000, **Lowell Technological Institute Research Foundation,** Lowell, Mass.

Research, design, and development leading to the fabrication and installation of a prototype display for earth satellites, $71,995, **All American Engineering Co.,** Box 1247, Du Pont Airport, Wilmington, Del.

Fabricate a prototype miniature missile magnetic tape recorder and playback system, $49,458, **Leach Corp.,** 18435 Susana Rd., Compton, Calif.

ARMY

U. S. Army Ordnance Dist., Los Angeles, 55 S. Grand Ave., Pasadena, Calif.

Fuze, $514,025, **Harvey Aluminum Inc.,** 19200 S. Western Ave., Torrance, Calif.

Catapult assemblies, $52,050, **Harvey Aluminum Inc.,** 19200 S. Western Ave., Torrance, Calif.

Guided missile, $30,800, **Firestone Tire and Rubber,** 2525 Firestone Blvd., Los Angeles 6, Calif.

Research and development, $7,551,962, **CalTech,** 1201 E. California St., Pasadena, Calif.

Design and development, $373,269, **North American Aviation,** Rocketdyne, 6633 Canoga Ave., Canoga Park, Calif.

Design and development, $49,732, **Rheem, Mfg. Co.,** 9236 E. Hall Rd., Downey, Calif.

Analysis of fuel developments and rocket engine designs, $68,598, **Aerojet-General,** Azusa, Calif.

Redesign of rocket and launcher, $48,103, **Bridgeport Brass Co.,** 3016 Kansas Ave., Riverside, Calif.

Feasibility study, $5,347,428, **Convair,** Pomona, Calif.

Guided missile, $44,800, **Firestone Tire & Rubber,** 2525 Firestone Blvd., Los Angeles 54, Calif.

Research and development, $17,833,870, **Sperry Rand Corp.,** Sperry Utah Engineering Lab. Div., 322 N. 21st West, Salt Lake City, Utah.

Sergeant missile, $14,320,690, **Sperry Rand Corp.,** Sperry Utah Engineering Laboratory Div., 322 N. 21st West, Salt Lake City, Utah.

Hypersonic research, $30,000, **CalTech,** 1201 E. California St., Pasadena, Calif.

Study of satellite rendezvous, $44,990, **North American Aviation,** Missile Div., 12214 Lakewood Blvd., Downey, Calif.

Hyperthermal research tunnel development, $99,061, **Plasmadyne Corp.,** 3839 S. Main St., Santa Ana, Calif.

NAVY

Navy Dept., Bureau of Aeronautics, Washington 25, D.C.

Research and development of missile-aircraft interference study, $39,085, **Sperry Rand Corp.,** Sperry Gyroscope Div., Sunnyvale, Calif.

Navy Dept., Bureau of Ordnance, Washington, D.C.

Modify 600 Loki darts to Hasp meteorological rocket head and payload assemblies, $69,212, **Cooper Development Corp.,** Monrovia, Calif.

Rocket engines, $100,332, **Aerojet-General,** Sacramento, Calif.

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